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Partnerships for Sustainable Forest Ecosystem Management

**General Technical
Report RM-GTR-266**

Fifth Mexico/U.S. Biennial Symposium

October 17–20, 1994
Guadalajara, Jalisco, Mexico

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Abstract.—This proceedings is a compilation of articles, presentations, case studies, and posters given by researchers and managers from the United States and Mexico. The symposium's purpose was to (1) share information that promotes forest sustainability and (2) build research-management partnerships among natural resource managers, scientists, landowners, policy makers, and public constituencies to address issues related to sustainability.

Keywords: sustainability, ecosystem management, international forestry, forest management

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Preface

Dr. Denver P. Burns[1]

Mexico and the U.S. have enjoyed a long history of institutional collaboration and cooperation in many forestry-related disciplines. Official records of this bilateral activity go back as far as 1911, that is, six years after the Bureau of Forestry was established to manage the expanding Forest Reserve System, later becoming the USDA Forest Service of today. Around the same time, in 1917, Mexico first created the Bureau of Forestry, Wildlife, and Fisheries under the Secretariat of Agriculture and Development. These institutions, since they came into existence, have been exemplary role models of international cooperation and collaboration.

These agencies have signed several agreements on Forestry cooperation that have evolved along with their own institutional growth. Three of the most important agreements under which they base their cooperative activities are: The North American Forestry Commission, The Memorandum of Understanding on Scientific and Technological Cooperation in Forestry, and The Letter of Intent on Forestry Research. These agreements, particularly regional agreements of forestry cooperation, have been fundamental mechanisms under which several previous technical and scientific meetings were successfully held. Of historical importance have been the four previous symposia organized under the auspices of a regional agreement between SARH-INIFAP, the Rocky Mountain Forest and Range Experiment Station, and the Southwest Region of the USDA Forest Service: Management and Utilization of Arid Land Plants; Strategies for Classification and Management of Native Vegetation for Food Production in Arid Zones; Integrated Management of Watersheds for Multiple Use; and Making Sustainability Operational. Given the success attained, the sponsors of these previous symposia made the recommendation to broaden inter- and intra-institutional participation at these events, and to frame them within existing general agreements of forestry cooperation between SARH and the USDA Forest Service. Under this new framework the Fifth U.S./Mexico Symposium on Partnerships for Sustainable Forest Ecosystem Management was held in Guadalajara on October 17-20, 1994.

The purpose of this symposium was to share information that promotes forest sustainability, emphasizing research-management interactions, building partnerships, and the need for a transdisciplinary approach to sustainable ecosystem management. About 500 people attended the symposium, among them policy makers, resource managers, scientists, indigenous people, industry, and land owners. Symposium objectives were met and results indicated that in order to make sustainable ecosystem management an operational concept, a new approach is urgently needed. In particular, an approach that goes beyond orthodox conceptions of scientific disciplines is required, one that calls for synthesis and convergence integration of many different disciplinary perspectives. Central to this approach is that no discipline has intellectual precedence over any other, especially in an endeavor as important as achieving sustainability.

Many institutions and people from Mexico and the United States made this symposium an impressive international example of work in partnership. Thanks to their efforts, this symposium was a complete success and a very special experience where partnerships for sustainable ecosystem management were truly emphasized and visited during the field trip to the forests of Tapalpa, Jalisco. Symposium participants had no doubts that bilateral symposia, such as this held in beautiful Guadalajara, have been a fundamental means for assuring continuity and success of present and future programs of forestry cooperation and collaboration between our countries.

[1] *Director, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service.*

OPENING REMARKS

Components of successful ecosystem management

Adela Backiel[1]

I am honored to represent the United States Secretary of Agriculture, Mr. Mike Espy, at this conference that highlights our enduring partnership in an area of vital concern to both the United States and Mexico: sustainable forest ecosystem management. Our many agreements illustrate our good working relationship and our common goals, specifically our Memorandum of Understanding, the research letter of intent, and the most recent U.S./Mexico bilateral framework for coordination.

On this occasion, when we celebrate the new understandings and practices gained for sustainable forestry through our common work, I'd like to briefly share what we believe are important components to the success of ecosystem management.

1. Science based. Ecosystem management is a policy that embraces the complexity of scientifically based sustainable management over the course of time. It is the integration of the human, biological, economic and physical factors in our planning and projects. The underpinning of good resources management in the United states has been and will continue to be scientific information on management options.

One way the Forest Service is strengthening the science base is through "state of the science" habitat conservation assessments for:

1. Forest owls,
2. Pacific Coast anadromous fish,
3. Small forest carnivores (lynx, wolverine, martin, and fisher),
4. Bull trout,
5. Inland cutthroat trout,
6. Northern goshawk, and
7. Marbelled murrelett.

Similar efforts to obtain the best scientific information are underway for ecological processes, vegetation and disturbance patterns, and expanding knowledge of the human dimensions of ecosystem management.

2. Public participation and a variety of perspectives. We're improving public involvement, for greater incorporation of public needs in our management activities. This change requires a highly paticipatory process for involvement of all U.S. publics from the time we decide to collect data, through analyses, modeling, alternative formulation, evaluating alternatives, and describing our selected resource management process.

3. Partnerships. We're expanding collaboration and partnerships. Agency personnel are committed to working with more partners, and a broader array of partners, than in the past. For example, the Forest Service is working with both national and international partners and other U.S. land management agencies to coordinate projects aimed at demonstrating ecosystem management, and for developing coordinated policies and plans across large landscapes. These three components of ecosystem management will enable us to achieve the desired outcomes to our national implementation of ecosystem management:

- The enhanced protection of ecosystems;
- The restoration of deteriorated ecosystems; and
- The provision of a variety of benefits within the capabilities of ecosystems.

In conclusion, we understand that sustainable resource management is an evolving activity within the United States. It rests on a national policy, an ecosystem management approach. And we're making changes and progress, with the help of many partners, including many Mexican colleagues present here today.

The United States shares a 2,000 mile border with Mexico, many migratory species, natural resources, economic trade, and cultural identities—so it is gratifying that we also share in the pursuit of new knowledge and new management approaches for sustainable forests.

Thank you again for this invitation to talk with you and to hear about our joint accomplishments.

[1]*USDA Deputy Assistant Secretary - Forestry.*

Working together

Jerry A. Sesco[1]

Good morning and welcome to the distinguished inaugural speakers with whom I share the diaz—especially Governor Rivera. And, welcome to all of you, my esteemed colleagues and friends.

I'm delighted once again to be in Mexico—in the well-known and progressive State of Jalisco and in the lovely and romantic city of Guadalajara.

I understand that there is an old Mexican proverb which says that "he who has been touched by the dust of Mexico will never again find peace in any land." This is no exaggeration. Ever since I first came to Mexico a few years ago, I find that I want to come here more and more. There is something magnetic and wonderful about Mexico.

Being here in Guadalajara today brings back memories of a significant event. It was here in July 1992 that the leadership of INIFAP and the U.S. Forest Service signed an agreement for focused collaboration in research. Since that occasion, we have watched research groups form and develop joint proposals, followed by conduct of joint studies. One year later, in July 1993, the Supplement to the Memorandum of Understanding with the Subsecretaria was renewed and created a new administrative framework for our bilateral work planning.

This new framework now brings land managers and scientists to the same table to develop and prioritize activities. In short, it enhances partnerships. Being in a partnership means that we have a shared—or common—vision of what we wish to accomplish. It is my opinion that science which doesn't ultimately contribute to better ways of doing things is sterile and land and forest management that doesn't use new and evolving scientific knowledge is, in the long run, ineffective and inefficient—and may lead to social, economic, and environmental harm.

So I believe it is obvious why this is a symposium emphasizing partnerships. This symposium brings together managers, scientists, land owners, policy makers, and citizens so that information about sustainable forestry can be shared. This will be done largely through hearing about actual case studies built on partnerships for sustainability.

Our national policy for sustainable forestry in the United States is being implemented through an ecosystem management approach. We define ecosystem management as a process which sustains both diversity and productivity of ecosystems while meeting people's needs for livelihood. More than 40 years ago, forester and wildlife biologist Aldo Leopold said that people should take care of the land as a "whole organism" and try to keep all the cogs and wheels in good working order. If we did this, he implied, all the things we value from the land would fare well.

As we work together, we need to enlarge and extend the geographic and temporal scales of our research and management. We need to strengthen interdisciplinary work and partnerships with land owners. We need to be giving more attention to the monitoring of our actions. We need to "manage by experiment" or "learn as we go." In the United States, we call this concept "adaptive management."

It is a cliche, but nonetheless profound, that our world is becoming smaller. Our borders are increasingly transparent to our economic development, our social development, and our environmental health. Resource policies in the United States and Mexico are converging in order to support our converging economies and societies. And we are pleased that our partnership in research—strengthened through joint interdisciplinary planning with land managers, is likewise promoting the convergence of our science and management.

On behalf of Jack Ward Thomas, Chief of the U.S. Forest Service, I extend best wishes for a successful meeting. Much work has gone into this symposium. I know it is going to be successful. So, I'd like to extend my personal thanks to everyone involved in the preparation. I look forward to our time together and thank you for the honor of helping open this symposium. Thank you.

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[1]Deputy Chief for Research, USDA Forest Service, Washington, D.C.

Partnerships for sustainable forest ecosystem management

Charles Cartwright[1]

Buenos dias! I can't think of a better time to be in Guadalajara.

First, I understand this week is part of Guadalajara's Fiestas de Octubre—a time to share history, art, music, and culture. Fiesta in many cultures is a very human celebration of people's ties to the land and is often at harvest time. Secondly, this week our two countries meet for the fifth biennial symposium to exchange forestry and ecosystem management technolgy, and share the many success stories we have accomplished together since our last symposium in 1993. Again, we must emphasize the inseparable tie of people to their ecosystems.

Plus, I look forward to Thursday when we start planning our next symposium and new projects.

In the Southwestern Region of the Forest Service, U. S. Department of Agriculture, we define ecosystem management as multiple-use management that integrates the needs of people with environmental values in such a way that the National Forests and Grasslands represent diverse, productive, and sustainable ecosystems.

Clearly, our management philosophy establishes ecosystem management as a human endeavor, seeking the well-being of people and communities as well as ecosystem health. The critical issues pertaining to ecosystem sustainability are inherently human issues. Issues such as global change, acid deposition, endangered species, and forest health stem from human activity, are issues because of human concerns, and must be addressed through human ingenuity and collaboration.

Other issues such as population growth, changing family structure, community integrity, and economic sustainability are intertwined with the physical/biological issues and must be addressed with the same ingenuity and collaboration.

[1]*Regional Forester, USDA Forest Service, Southwestern Region.*

There are four key components to our ecosystem management strategy. They are:

- Partnerships with people.
- An ecological approach.
- A foundation of scientific information.
- Public participation in decision-making.

In each of these areas, we have opportunities to work with our Mexican colleagues.

PARTNERSHIPS WITH PEOPLE

We have an ongoing partnership with the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP) and Secretaria de Agricultura y Recursos Hidraulicos (SARH) to exchange scientists and technicians in research on mutual issues and management.

We are working with Colorado State University, the Rocky Mountain Station, and INIFAP on a study of cultural ties to ecosystems and ways to involve people from all cultures in ecosystem management planning. We have a volunteer program that facilitates the exchange of technicians for on-the-ground implementation of ecosystem management.

AN ECOLOGICAL APPROACH

We defined eco-regions and sub-regions of the United States that must be extended into Mexico for broad-scale planning on regional scales. Planning on ecological scales rather than stopping at international boundaries or property ownership lines will help us better define regional issues and ecosystem interactions. The air and watersheds that affect our two countries pay little attention to human boundaries.

A FOUNDATION OF SCIENTIFIC INFORMATION

We continue to share scientific information through our joint symposia and research publications. We can apply this shared information and monitor the results. We can share adapted information based on our monitoring in the future. There are opportunities to share and coordinate our monitoring programs so our information is more mutually meaningful and useful.

PUBLIC PARTICIPATION IN DECISION-MAKING

We continue to seek ways to bring all people and cultures into collaborative processes for decision-making. We realize that different means of participation are more comfortable for different people. There are opportunities to share successful experiences among countries for possible international applicability. Communications among the human communities of interest are essential throughout the ecosystem management decision processes.

Mexico and the Southwestern Region of the United States share much in our common life-support systems. We also have a long, successful history of working together. We are doing a good job communicating, but we can do more. We must continue to learn, share technology, and manage to insure sustainability of our life-support systems for ourselves and our future generations.

INVITED PAPER PRESENTATIONS

Sustainability: A matter of human values in a material setting

T. F. H. Allen[1] and Thomas W. Hoekstra[2]

Abstract .—This paper decomposes the issue of sustainability into three parts. First we lay out the philosophical basis to the approach we take. Second we identify the problems of dealing with a biophysical structure that, in the conventional view of sustainability, is the thing to be sustained by ecologists, conservationists and resource managers. Third we identify that all will be lost unless the social context of the biophysical system is brought to a sustainable condition. Only when our intellectual framework is laid out, can the special utility of our point of view be recognized. Only when one understands the difficulties of dealing with complications of the mechanics of the plants, animals, soil, climate and their interactions can we hope to take action that has predictable consequences. Only when the manager operates in a sustainable social setting, one of social justice and economic viability, can one hope to have the planned course of action be sustained.

THE PHILOSOPHICAL POINT OF DEPARTURE

Because ecologists and resource managers deal with things that they can see and touch, such as trees and rivers, there is every temptation to imagine that humans engaged in a search for sustainability deal with material reality (Allen and Hoekstra, 1992). Of course there can be no such thing as making observer- free observations, and practicing scientists would no think otherwise. Modern philosophies of science emphasize that data are only a matter of observation. The practical implication of such philosophies seek actively to avoid behaving as though data are exactly equivalent to external reality. Observation does not give the scientist access to the real system, only a system that arises as the interaction between the value-free material system and the value-laden observation protocol of the observer (Allen and Hoekstra, 1994). We are prepared to admit that there probably is a real world independent of human observation and values, but as humans we are all denied direct access to it.

This may seem to be an esoteric point that has little to do with saving the planet from ecological destruction. However, the scientist who suppresses the role of the observer in data ends up with wrong predictions. This is demonstrably the case in the hard sciences like particle physics. The strange equations in quantum mechanics lead to some very counter-intuitive notions of observation and reality (Allen and Starr, 1982). The bottom line is that we never observe an independent material system, we only get to observe a system that is being observed. Scientific observation cannot escape a subjective component. It is therefore best to acknowledge subjectivity and keep it all the time as a working partner in the process of scientific resource management.

The subjectivity in scientific observations relates to matters of sustainability in two important ways that lead directly to the points of tension raised in the rest of this paper. First, there is always an observation protocol that employs scaling factors,

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although matters of scale are separate from the observer's decision as to what is in the foreground as the central object of the investigation. Second, sustainability does not exist independent of human values.

As to the first issue of scaling versus type of system in the foreground, all structures are arbitrary assertions of the observer, even those that feel concrete and real. In sustainability the structure is the thing to be sustained, as opposed to a very large number of other things that might be candidates, but have not been chosen. This first issue is discussed in the next section of this paper.

As to the second issue of human values, sustainability is not a relevant concept until there is a significant human component to the material system. Pristine nature is a pleasing thought, some far off, untouched piece of creation. However, unspoiled nature is a mythical state that has no importance in a world that is home to over five billion people (Allen and Hoekstra, 1994). If nature is left to do what it has always done, then sustainability is an academic matter. Sustainability involves an active pursuit of a goal. In technical terms, sustainability requires an objective function. Without an explicit value statement in it, sustainability has no meaning. There is some desired condition that is valued more than some other condition; the former is to be sustained, and the emergence of the latter implies a loss of sustainability. We look to the issue of human values as an integral part of sustainability toward the end of this paper.

THE BIOPHYSICAL SYSTEM

Observing the biophysical system

From the traditional purview of the ecologist and resource manager, the thing to be sustained is the biophysical system. This system has its organisms from elephants to insects, and its physical aspects, like water quality. It is easy to capitulate to some undefined material whole, and say we must sustain everything (Allen, Bandurski and King, 1993). However, such a course is not possible, and it has no meaning. If we did manage to sustain everything, as humans with limited powers of knowing, we would have no means to see that we had achieved such a goal. Alternatively, if we had failed to save every aspect of everything, we would not be able to see much of the manner of that failure. No! Sustaining every aspect of a material system is so far from being an option, that some other course of action must be taken. Nothing can be achieved until the manager accepts responsibility for decisions of scale and system type.

All observations are set in the context of an observation protocol that implies some model of the material system. Any observer is free to erect any framework, but there are some useful frameworks that come from a fairly small set of conventional wisdoms. Some of these conventional frameworks come from ecology, and embody the subdisciplines of organismal, physiological, population, community or ecosystem ecology. All of the above frameworks define the type of system that is to be sustained, independent of scalar considerations. Each of these subdisciplines have their devotees, and remain remarkably separate from each other (Allen and Hoekstra, 1992). Each brings out some aspect of the system, and each has something to contribute to achieving sustainability. In general it is quite hard to work with hybrid frameworks that fall between the subdisciplines, but it can be achieved with the exercise of some imagination.

Let us distinguish between a couple of the conventional frameworks to show how each leads to sustaining a distinctive aspect of the material system. In the following comparisons and contrasts, we emphasize that the definitions of community and ecosystems that we use are our own, and we do not wish to impose them on others. The reader should consider them as operational. The exercise is not a matter of finding a set of proper definitions, but is rather an illustration of the how reasonable, relatively orthodox definitions lead to very distinct conceptions and courses of action. All of the conventional frameworks are very incomplete accounts of the full and inaccessible material whole, but that incompleteness comes with the scientific treatment of any problem. Science is precisely not a matter of seeking to understand everything, but is rather a matter narrowing frameworks to that predictability can emerge.

A community view focuses on collections of organisms of different species that accommodate to each other and form a stable, multispecies

whole. This view takes the other respective kingdoms to be the biotic environment. For plant communities it is the animals that eat, trample, pollinate and disperse the community members. For animal communities, the biotic environment consists of plants that make up animal resources and the habitats. Separate from each community's biotic environment is the physical environment. The community view emphasizes the separateness of community and environment. Within the community, competition, mutualism and other factors that pertain to evolution and adaptation are key processes. Sustainability of communities is significantly distinct from sustainability of populations, ecosystems or landscapes.

Let us contrast an ecosystem view with one that employs the community as the organizing principle. Ecosystems, by our definition, include the biotic and physical environment as part of the system. This view of ecological systems changes the tools that can be used to study such systems from those important in community studies. In communities, the adaptations of organisms are central, whereas in process-functional ecosystems, adaptations and evolution are singularly unimportant. With the environment inside the system, organisms significantly melt away into pathways of energy flux and material flow. In an ecosystem, cows might as well have no sex or color. They may well not even be distinguishable from horses. In an ecosystem, cows are the connection between teeth and anus, they are the converter of green plant material into detritus.

The tools of choice in studying ecosystems address material and energy flows. Principles such as mass balance and conservation of matter allow ecosystem calibration (Allen, O'Neill and Hoekstra, 1987). Used carefully, they can detect nutrient leakage or accumulation. In communities or populations, mass balance is not violated, but it is unimportant. The fact that deer in a population eat the same amount as they respire, urinate and defecate tells nothing of their adaptations or role in the community. Conversely, the organisms that exist anonymously in ecosystem nutrient cycles are the product of evolution, but that can usually be safely ignored.

In matters of sustainability, a community view is very different from one that comes from an ecosystem perspective. In the final analysis, a community cannot exist if its commensurate ecosystem is defunct. Furthermore, there can be no ecosystem if there is no mode of primary resource capture. Without plant communities, there is no primary productivity, a crucial aspect of ecosystem function. Even so, despite these ultimate co-dependencies, it is perfectly possible for an ecosystem view to detect immediately that the system is not sustainable, while the community may show no signs of stress or dysfunction whatsoever. In other circumstances, a problem that appears on the face of it to be a community in trouble might be better explained in ecosystem terms.

As a case in point, in the loss of salmon fisheries on the Pacific Coast of North America, the first impression was that overfishing had destroyed the breeding stock. The symptoms looked for all the world as though it was a non-sustainable population or community. Further investigation showed that it was not live salmon numbers that were too low to lay eggs, for the few fish that do make it to the spawning grounds lay more than enough eggs to make a cohort. It emerged that the missing factor was a sufficiency of dead salmon, expired after returning to lay eggs. Dead salmon are the product of a reverse nutrient pump that makes up for the flow of minerals downstream. Dead salmon rot to give phytoplankton growth that supports zooplankton, which in turn feed the hatchling salmon (Hyatt and Stockner, 1985; Stockner, 1981). The loss of sustainability is of the ecosystem, not the population or the community. The solution is artificial addition of mineral nutrients, and the fish could do the rest of the job of recovery.

Scaling decisions for the biophysical system

Because this planet will be consumed in an expansion of the sun in some billions of years, absolute sustainability for all time is a moot point. Of course, our species will be extinct long before our sun does its worst. However, this does mean that there are limits, and once we acknowledge any limit, we must decide which ones are important and which are incidental. Sustainability has a temporal extent for each condition, beyond which we acquiesce. The observer must decide what is important and for how long (Allen and Hoekstra, 1994).

Since there is no such thing as sustainability for all time, it is important that anyone planning toward sustainability do so with some time frame in mind. While Methuselah lived nine hundred years, most organisms live for much shorter time spans. Issues of sustainability need to take into account the inherent temporal spans of organisms and other parts of sustainable systems. Furthermore, were Methuselah a resource manager, he would probably have a very different agenda for his efforts toward sustainability than would the rest of us mortals with our three score years and ten.

Thus sustainability involves not just the temporal spans of the biological organisms or other parts of the biophysical system, but also it must be planned around the temporal spans of the relevance of societal values that are implicit in sustaining the biophysical world in the prescribed manner.

Much as temporal scaling is a crucial part of decisions toward sustainability, spatial scaling matters as well. One might argue that the restoration of the Curtis prairie in the University of Wisconsin Arboretum is inadequate as an effort to sustain tall grass prairie because it supports no buffalo. Indeed buffalo are absent, but the prairie, wonderful as it is, is only a slightly larger area than a moderate sized agricultural field for the region. It is not that buffalo are missing from the community restoration, it is that the area is not great enough to include them. Thus the appropriate biophysical character of that which is to be sustained is dictated by spatial area. The futility of aiming at sustainability without setting spatial bounds can be made clear by taking the argument to its absurd logical conclusion: it makes no sense to complain that the Alaskan wilderness inadequately sustains the biophysical system because it contains no tropical rain forest. Sustainability must always be planned for some scale-defined situation (Allen and Hoekstra, 1987).

Often there will be a relationship between the spatial and temporal aspects of sustainability (Allen, O'Neill and Hoekstra, 1987). Large areas are likely to have an appropriately long time line as part of the program, while small areas may be adequately sustained as relatively ephemeral systems. For example, in a study of a microcosm, sustaining it for a few months could easily be fully adequate for the purposes at hand. On the other hand, an appropriate time span for a plan to sustain a large forest would probably be at least a millennium.

SOCIAL JUSTICE AND ECONOMIC VIABILITY

Joel Cohen once wrote that biologists have physics envy. That is probably true, and to make matters worse they envy Newtonian tidiness over the penetrating logic of quantum mechanics. In ecology this manifests itself in an illusion that the scientist's appropriate agenda is to find out what is really happening in the material system in the manner that ecologists imagine physicists do. As we have already asserted, above and elsewhere (Allen and Hoekstra, 1992), science may be approaching some ultimate reality in its models, but that is not relevant to the conduct of scientific inquiry. If scientific models do represent movement towards ontological reality, the approach must be so infinitesimal that it is hardly something upon which to base the criteria for success of the enterprise. Even so, there is a pecking order to resource scientists that holds in its highest ranks those scientists pursuing the hardest sciences with the most direct physical measurements, and puts at the bottom those who deal with the soft end of resource management. Soft resource management addresses issues like land ethics, where human values are everywhere.

Sustainability cannot be properly considered unless the soft end of the problem is included as more than a token. Lynton Caldwell has said that one does not directly manage the biophysical ecosystem; rather the manager influences the people who act on the system. Therefore, if the human side of the equation cannot be sustained, then neither can any other part of the project. The human part of sustainability can be effectively divided into two. One half is economic and the other is social justice.

Sustaining any biophysical system involves direct human activity of an economic sort. Perimeter fences around parks take money to erect, as do guards and wardens to protect a game reserve. Even if some aspect of sustaining a system does not involve actively spending cash, it could

equally involve foregoing resources that would give direct economic advantage. To the party making the sacrifice, money not made is the same as money spent. If biophysical resources are to escape destruction from exploitation for short term profit, there must be other resources that are offered as compensation. That of course demands some sort of economic system that is in a position to support the exercise of discipline and restraint. Dan Janzen has been saying for some time now that any tropical rain forest that does not in some fairly direct way pay for itself will be gone in a few decades. There are enormous pressures for wood, grazing land and minerals in marginal local economies of the tropics. National governments responding to international entreaties to preserve genetic and ecological resources need compensation. That compensation consists of economic resources that should be directly coupled to the acts of restraint that allow tropical forests to be sustained. There is an explicit economic aspect to sustainability. A stable and adequate economic base is a requirement for sustainability.

Beyond economics, social justice is also a crucial component, although justice and economics may be linked. Without social justice, reasonable people cannot be expected to exercise measured stewardship. Preservation of ancient varieties of crops from isolated agroecosystems cannot be achieved with any reliability in germ plasm banks of industrial nations. The only place that such crucial materials can be sustained is in their place of origin. On the other hand, who is going to be prepared to live in what amounts to an agricultural museum to keep ancient methods of husbandry alive in a world that beckons with consumer opportunity? The first world must pay a fair price for genes and the rare pharmaceuticals from the isolated places that have thus far escaped progress.

Beyond direct economic aspects of social justice, sustainability of biophysical systems requires stable social settings that arise from societal members perceiving the situation as worth their cooperation. War lords make very poor conservationists. A small disgruntled section of a society can start feedback processes going that lead quickly to out and out social strife. The olive branch as a symbol of peace derives from olive groves in the Mediterranean being safe havens for routed armies. The victors would not press pursuit into the olive grove because it was a valuable biological resource that once destroyed would take decades to replace. However, the olive grove is an exception, for social upheaval generally destroys fragile biophysical resources. Therefore, social justice that leads to social stability must be part of a realistic program for sustainability.

CONCLUSION

The issue of sustainability requires a precision of thought. It must avoid myths and easy ways out. It is clear that sustaining everything for all time is worse than impractical; it is meaningless. Reference to some pristine system as a pie-in-the-sky ultimate goal is also impractical and meaningless. Sustainability does not become an issue until there are humans with values inside the system. Human values are an integral part of sustainability; the mythical, completely objective scientist is particularly inappropriate in matters of sustainability (Allen, Bandurski and King, 1993).

Since there are limits to what is possible and desirable, the resource manager and scientist must take responsibility for bounding the system to be sustained in both time and space. Also, the type of system that is to be sustained cannot be left implicit and unstated. Like the issue of scale, the type of system that is the object of action needs to be laid out clearly in the mind of the planners, and then stated clearly for those who are to execute the remedial or holding action. Sustainability is not something that will happen if we just leave things alone and let nature take her course. There is an imperative call to action with some explicit goal in mind that comes from openly stated agenda and values.

Those who address sustainability cannot afford to focus narrowly on just the ecology of the biophysical system. Meaningful planning must at least take into account all the stakeholders in efforts to sustain a natural resource system. Where possible stakeholders should be party to the decisions that are made (Checkland, 1981). Planning must be done cognizant of the social system that is the context of the biophysical system. While narrowly focused biologists or academic ecologists do have something to offer a world that seems bent on destruction, now is no time for scientists to

retreat to delusions of objectivity and accurate measurement of material truth. The sciences that come to address sustainability need to put aside narrow agendas.

Effective sustainability will come not from grasping an objective truth, but from casting about to find powerful points of view. Now is the time for expansive thinking that reaches out to embrace a world full of rich differences in human needs, values and aspirations. In such a challenging place, students of resource management need a sound philosophy of knowledge. They must have a clarity of thought that uses that philosophy to achieve understanding that can lead to action with beneficial, predictable consequences. Now is no time for clinging to scientific myths or a retreat into academic myopia. But now is the time for forging a new collaboration between natural and social scientists, if we are to have a chance of a desirable, sustainable future.

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The scientific basis for sustainability

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Abstract.—In this paper we present a general overview of the scientific basis for sustainability. This concept is understood to guarantee the use and conservation of natural resources in the long run. Sustainability in forest resources management should be compatible with both physical and biological ecosystem integrity. Sustainability must also satisfy human needs throughout designed strategies of natural resources use. Sustainability is part of the "sustainable development" concept, defined as creating land use opportunities for the present without compromising the ability of future generations to have the same opportunities. It is established knowledge that sustainability is based on biological sciences, economic sciences, social sciences, political sciences, and technology. An analysis of this integration can produce strategies for sustainably managing forest resources in the context of ecosystem management.

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Sustainability: How much?

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Abstract.—The concepts implied by the term "sustainability" have been present since forest sciences and related techniques began. Now, society as a whole has become involved in that interest, which has brought a new interdisciplinary focus.

Without being restrictive, we propose that the following be sustained: (a) meeting human needs (b) biodiversity; (c) soils and the subjacent layers (d) air and atmosphere; (e) water; (f) climate and energy flows; and (g) the interaction of all of the above. A crucial question arises: How do we want to conserve these items? Do we conserve them as they are now, or as they were many years ago? It has to be a consensus based on the best available knowledge of sustainability paradigms. Any such consensus must include economic sustainability and social acceptance. The demand for sustainability results from human interest at three levels: (a) humanity's habitat (biosphere); (b) humanity's organization (societies or countries); and (c) humanity's individual members. In spite of being too anthropocentric, such a proposition can be accepted after some arguments. In any case, a sustainable scheme must be congruent among those levels.

It is urgent to define "sustainability descriptors," which should have the capability of being quantified. Available knowledge is insufficient to quantify the descriptors right now. But it is necessary to define a set of descriptors and continuously review them if we want to move from wordy discussions to operative guidelines for sustaining forest resources for humankind now and into the future.

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Concepts, criteria, and indicators for monitoring sustainability

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Abstract.—The biosphere provides three basic services to humankind: production of natural resources, waste assimilation, and environmental services. Current economic developments are taxing the biosphere's capacity to supply those services because the magnitude of the negative impact of human activities on the environment has not been fully recognized. Sustainability is achieved when the service capabilities of the biosphere are not violated by our economic activities. Monitoring programs help us determine if/when human economic activities exceed the biosphere's service capabilities. Four broad categories of environmental indicators for natural resources include: response indicators, exposure indicators, habitat indicators, and stressor indicators. These indicators and criteria for their selection are essential in the development of an environmental monitoring program.

The natural environment or biosphere performs three principal functions for the economic activities of humankind (Jacobs 1991). First, it provides us with three principal types of natural resources: non-renewable resources—such as coal, oil, gas, minerals and other materials; renewable resources—such as water, air, plants and animals; and inexhaustible resources such as the sun's energy which is harvested by photosynthetic organisms. Second, the biosphere assimilates the waste products of human and natural activities through processes such as carbon sequestration, nitrogen cycling in forests ecosystems, and water filtration and purification. Third, the biosphere provides us with various environmental services. Some of these environmental services are traditionally ignored in economic analyses because they lack a direct market value. One of these services consists of the amenities that we consciously and directly use, such as space for recreation and aesthetic enjoyment, and wildlife habitat. Life support functions such as regulation of climate and the gaseous composition of the earth's atmosphere or maintenance of genetic diversity, that are necessary to maintains the biosphere can be considered another type of environmental service (Jacobs 1991). Without these environmental functions no economic activity would be possible.

Many of the environmental problems challenging human society are fundamentally ecological in nature (Lubchenco and others 1991). The growing human population and its increasing use and misuse of resources are exerting enormous pressure on the Earth's life support capacity. We must develop knowledge to conserve and manage wisely the Earth's natural resources. Everyone—including citizens, policy makers, resource mana-gers, and leaders of business and industry—make decisions related to the Earth's resources, but such decisions cannot be made effectively without a fundamental understanding of the effect of our activities on the Earth's biosphere. By establishing specific goals or targets for biosphere capabilities and ensuring that our economic activities do not violate those targets,

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Sustainability will be achievable. It is clear that these goals or targets can not be absolute values; they will vary depending on the environmental conditions and whether the natural processes are declining, maintaining or increasing. Monitoring is the mechanism through which compliance with the established targets can be ascertained.

This paper discusses the concepts of monitoring, indicators of and environmental health, and sustainability and how they relate to economic development, as well as the implication of the present economic development paradigm on the sustainability of the biosphere.

ENVIRONMENTAL HEALTH AND SUSTAINABILITY

The health and sustainability of the natural environment or ecosystems are very important not only to the well being of humankind, but to nature itself. However, both the terms "ecosystem health" and "ecosystem sustainability" are difficult to define and even more difficult to operationalize. Many articles and books on the subject have been written, but many researchers do not agree on what these terms mean, or even how to measure or monitor them (Gale and Cordray 1991, Hunsaker and Carpenter 1990, Kelly and Hardwell 1990, Kessler and others 1992, Lubchenco and others 1991, SAF 1993, Schaeffer and others 1988, Schreckenberg and Hadley 1991, Udo de Haes and others 1991). Schaeffer and others (1988) state that

> "...The assessment of ecosystem health requires the identification of a systematic set of relationships which will provide the basis for organizing data from various disciplines... The objectives are the initial definition of a healthy state, the selection of parameters which allow quantification of state or condition, and the identification of criteria which allow assessment of relative health."

As Schaeffer and others (1988) describe, no single parameter has sufficient diagnostic power to indicate the health or status of an ecosystem. The additional cost of multiple indicators to assess ecosystem health presents a challenge, particularly in those developing countries with limited financial resources and pressing social needs.

The concept of sustainability is equally difficult to define. Generally the concept of sustainability is related to a sustainable relationship between society and the environment (Udo de Haes and others 1991). The World Commission on Environment and Development (1987) goes further in stating that present levels of development can only be sustained if the integrity of the biophysical environment is protected. The problem is that a sustainable relationship between society and the environment might take place at a level of poor quality of either society (development level), such as in developing countries, or the environment (environmental quality), as in highly polluted industrial areas. In some cases, societal development and environmental protection are both threatened by factors such as eroded mountainous areas in developing countries, or slums surrounding large cities in the industrialized world (Udo de Haes and others 1991). To define or measure sustainability we have to consider quality standards for societal development as well as for environmental integrity. We must also define the desired equilibrium between the two with regard to the environment.

The issue of sustainability is further complicated by the lack of rigorous scientific information that can be applied in the decision making-process. This is demonstrated by the paucity of work addressing such critical issues as long-term soil capability after repeated logging cycles, or the cumulative effects of timber management practices at either the landscape, regional, or provincial scale (Dunster 1992). The recent emphasis on adaptive management practices based on ongoing management/research cooperative projects, will hopefully lead to more knowledge-based management for forest sustainability. In adaptive management programs, management activities are conducted as experiments to test hypothesis and develop information for future natural resource management (Swanson and Franklin 1992). Adaptive management research programs provide scientists with the unique opportunity to perform manipulative large-scale studies, and will also provide forest managers with information needed for best managing forests for long-term health and sustainability. More than ever, management of natural resources requires knowledge about ecosystems, including relationships to human values, activities and patterns of resource use (Kessler and others 1992).

SUSTAINABLE DEVELOPMENT

The question can be asked, "sustainability for what purpose?" Gale and Cordray (1991) suggest at least eight different answers to this question for forest ecosystem sustainability, ranging from "Dominant Product" and "Human Benefit" sustainability to "Ecosystem Type" and "Ecosystem-Centered" sustainability. The answer to this question depends on the relationship between society and the environment. Maini (1990), also suggests that–sustainable development is a process that operates through the utilization of natural resources, and the direction of investment, the orientation of technical development and institutional structure; all of which are continually changing to maintain harmony and to enhance both the current and the future potential of the biosphere to meet human needs and aspirations. Thus these definitions may offer a clearer understanding of sustainable development, but they do not suggest how to achieve it!

Because economic development is needed to satisfy societal needs many analyses have focused on these paradigms to solve environmental problems. But these economic development paradigms do not fully address the negative impacts on the biosphere. One of the best examples of this today are the tropical regions of the world (as the temperate regions were in past centuries). As Schreckenberg and Hadley (1991) state, "...the sort of development that has taken place in many tropical regions the last few decades has caused widespread ecological problems such as loss of soil fertility and genetic impoverishment, to the extent that large swaths of land in the tropics are now lost to productive use."

In particular, tropical forests are not managed, but exploited, similarly to mines of minerals and ores. Resources are mined for the short-term with disregard for the long-term sustainability of the forest ecosystem. This is not an exclusive problem of developing countries. In the United States, for example, more than 1 billion tons of soil, net of natural replacement, are lost every year--an area equivalent to almost 300,000 hectares (Jacobs 1991).

The fact that the present patterns of economic development are environmentally damaging does not mean that the solution to our environmental problems is to curb economic development. No economic development, or a decrease in economic development could be equally damaging, and in some cases more damaging than economic growth (Udo de Haes and others 1991, Jacobs 1991). We need a definition of sustainability that allows compatibility between environmental conservation and the economic development needed to satisfy societal needs. On the basis of the definition of sustainability by the World Commission on Environment and Development (1987), and because of the need to define environmental protection Jacobs (1991) proposed the following operational definition of sustainability: "the environment should be protected in such a condition and to such a degree that environmental capacities (the ability of the environment to performs its various functions) are maintained over time; at least at levels sufficient to avoid future catastrophe, and at most at levels which gives future generations the opportunity to enjoy an equal measurement of environmental consumption."

In the case of providing renewable resources for example, as long as the rate of harvest does not exceed the regeneration rate, the resource stock is maintained, the environmental capacity of the resource is maintained, and therefore, sustainability achieved (Jacobs 1991). Similarly, for the assimilation of waste function, the basic rule for sustainability is that the flow rate (and concentration) of waste discharge should not exceed the assimilative capacity of the recipient medium. For the environmental services capacity the measurement of sustainability is more difficult, because the environmental services are not consumed like a renewable or non-renewable resource.

MONITORING

Monitoring environmental indicators can be used to record changes in the environmental capacity and its consumption (how much the environmental capacity has been reduced). Theoretically, by adopting limits or targets for the appropriate environmental indicators, and ensuring that the economic activity does not exceed these limits, sustainability can be use as an operational policy.

The concept of monitoring is sometimes applied, almost indiscriminately, to a range of disparate activities. From attempts to describe prevailing environmental conditions, and the occurrence, distribution, and intensity of pollution, to providing a brief on the countryside at large have been considered monitoring (Hellawell 1991). Adopting a clear definition of monitoring helps to ensure the design of a monitoring program. Hellawell (1991) offers the following three basic definitions:

- *Survey*—An exercise in which a set of qualities or quantitative observations are made, usually by means of a standardized procedure and within a restricted period of time.

- *Surveillance*—An extended program of surveys to provide a time series, and to ascertain the variability and/or range of state or values which might be encountered over time (but again, without preconception of what these might be).

- *Monitoring*—Intermittent (regular or irregular) surveillance carried out in order to ascertain the extent of compliance with a predetermined standard or the degree of deviation from an expected norm.

The major difference between monitoring as defined by Hellawell, and survey and surveillance, is that monitoring is intrinsically purposeful and presupposes an idea of the results that are expected. We are concerned with establishing limits, however arbitrary, and deciding what to do when the monitoring reveals the present situation is out of the norm or target. Even before any monitoring program is begun we need to consider five basic questions (Usher 1991, Roberts 1991):

1. **Purpose**—Why are we monitoring? What is the aim of the monitoring? Collecting data is not sufficient reason in itself. We need to specify the purpose of the data, i.e, what is the question we need answering. The intensity and frequency of the monitoring must also be considered.

2. **Method**—How can the aim be achieved? How to obtain the data? This includes choice of the sampling techniques, and any experimental manipulation.

3. **Analysis**—How will the collected data be handled? What data, tests, and analyses will be needed to answer the question asked? This includes determining the type of data required, sample sizes, and appropriate statistical analyses, if needed.

4. **Interpretation**—What might the data mean?

5. **Fulfillment**—When will our aim be achieved?

Types of Monitoring

In general, broad reasons for monitoring include: assessing the effectiveness of policy or legislation, regulatory (performance or audit function), and detecting incipient change (early warning) (Hellawell 1991). Depending on why we want to monitor, MacDonald and others (1991) have identified several types of monitoring. These types are not exclusive and are defined more by the purpose of the monitoring rather than the type and intensity of measurements.

- *Trend monitoring*—Used to measure particular parameters at regular time intervals to determine the long-term trends. Examples include measurement of climatic or water quality data.

- *Baseline monitoring*—Also called inventory or assessment monitoring, used to characterize existing environmental conditions and to establish a database for planning or future comparison. Examples include developing species inventories and inventories of wildlife habitat.

- *Implementation monitoring*—Used to assess whether activities were carried out as planned. Examples include site visits to determine if a project was implemented as specified in a contract or planning document.

- *Effectiveness monitoring*—Used to assess whether the specific activities that were implemented had the desired effects. Examples include measuring water quality changes before and after the implementation of best management practices like riparian buffer zones.

- *Project monitoring*—Used to assess the impact of a particular type of project or activity, such as a harvesting contract, and may include both implementation and effectiveness monitoring.
- *Validation monitoring*—Used to independently test the output of a model to provide an unbiased evaluation of the overall performance of the model.

Each of these types of monitoring have a role in monitoring for sustainability, and each have associated costs. Baseline and implementation monitoring are typically the most cost effective, while effectiveness and validation monitoring require the greatest scientific rigor and design.

INDICATORS FOR MONITORING FOREST HEALTH AND SUSTAINABILITY

General Considerations

According to Jacobs (1991), to measure sustainability two types of environmental indicators need set targets: those that measure quantities and qualities (stock) of the essential environmental features such as soils, forests, land use, water resources (fresh and marine), number and diversity of species, and others; and those indicators that measure the economic activities causing changes in the first type of indicators such as emission and discharge rates for pollutants.

It is important to monitor those indicators that help us evaluate whether an ecosystem is in a sustainable condition. Indicators which provide information on the "health" and vitality of an ecosystem, should also indicate the likelihood of sustainability. Recognition of the potential for change is implicit in the rational for most monitoring activities. We want to detect a change that has occurred, and establish its direction, and measure its extent or intensity. It is at this stage that monitoring of critical indicators of ecosystem health and sustainability becomes relevant. Long-term monitoring will be the most informative and the most likely to detect significant signs of ecosystem deterioration or unusual deviations from expected patterns of ecosystem state and functioning.

The use and implementation of indicators for monitoring ecosystem health is still evolving and requires further research and development (Lubchenco and others 1991, Schaeffer and others 1988). The number of proven diagnostic tools for assessing ecosystem health is low (Schaeffer and others 1988). No single indicator has sufficient diagnostic value to indicate the health or status of a forest. A combination of indicators, or in some cases a suite of indicators, is needed to provide a more comprehensive picture of ecosystem health and sustainability (Kelly and Harwell 1990).

Various criteria or guidelines for selecting indicators of ecosystem health has been proposed (Hunsaker 1993; Hunsaker and Carpenter 1990; Kelly and Harwell 1990; Riiters and others 1992). Indicators chosen for monitoring may be partly determined by the desired endpoints or characteristics to be sustained in the forest (e.g., biodiversity, timber, aesthetics and recreation, wildlife habitat). Ecosystem science has progressed to the stage in which general ecological principles and characteristics of "healthy" functional ecosystems are known. On the basis of that knowledge, candidate indicators of forest health and sustainability can be developed, employed, and further refined. Whatever indicators are ultimately used, we must carefully evaluate their response relative to the successional patterns of forest development. For example, stand growth rates, biomass allocations, nutrient pools and cycling processes, and the incidence of disease and pest outbreaks can change dramatically with the progression of stand development and succession (Grier and others 1989).

The key elements of a sustainable forest, according to the Society of American Foresters (1993), are the maintenance of biological diversity and soil fertility, and the conservation and dispersal of genetic variation. The Society's task force on Sustaining Long-Term Forest Health and Productivity (SAF 1993) recommended that the primary objectives for forest sustainability focus on the state of the forest. Stocks (e.g., timber volume, density of wildlife, miles of trail) and flows or yields (e.g., water, annual fiber production, pounds of anadromous fish) should be secondary concerns. These priorities are based on the premise that forests in a healthy functional state, will be best suited for long-term maintenance and support

of multiple environmental values. Indicators of forest sustainability should reflect the state of the ecosystem, with productivity as a secondary measure of sustainability. Provided that a diverse genetic base is intact, soil is the remaining base resource essential for forest sustainability. Powers (1989) reported that soil volume, soil organic matter and total soil porosity are major factors in determining the long-term productive potential of forest stands.

Interpretation of forest indicator responses should be considered within the context of past forest management, climatic and environmental stresses, land use, and stand history. For example, overly disruptive harvesting techniques can result in loss of topsoil and soil organic matter, soil compaction, and reduced soil porosity. The net result would be a significant degradation in the capacity of that site to grow vigorous trees, and could explain indications of deteriorating forest health. Knowledge of natural fire regimes, fire history in the current stands, or of fire exclusion and its possible effects on forest sustainability, can also be important considerations in maintaining and monitoring forest sustainability. Indicator responses suggesting decreasing forest sustainability may also be explained by additional information regarding stand history and management practices, episodes of climatic extremes, or severe pollutant exposures.

The development of sensitive indicators to evaluate forest health and sustainability with a high signal-to-noise ratio is a significant challenge. Sensitive indicators often show high natural variability. The lack of sensitive indicators of ecosystem stress limits detection of early stages of ecological change (Lubchenco and others 1991). Ecosystem degradation is often detected retrospectively ("after the fact"). Indicators of initial disease states or stress are needed to determine disease before symptomology reaches clinical magnitude (Kelly and Harwell 1990; Schaeffer and others 1988). Species level indicators usually respond more rapidly than process-level indicators. Effects on ecosystem functions implies prior associated effects on the biotic populations performing those functions. Thus, functional measurements of ecosystem processes (functional indicators such as productivity and nutrient cycling) are typically less sensitive indicators of ecosystem stress than are structural properties such as species composition (Kelly and Harwell 1990, Lubchenco and others 1991). However, functional indicators show longer-term consequences, perhaps forewarning irreversible change (Kelly and Harwell 1990).

Analogy to Human Health

Physicians routinely measure body temperature, blood pressure, heart rate and weight to monitor the general fitness of their patients. In forest health monitoring, analogous parameters include annual height growth, live crown ratio, leaf area, and needle retention for single trees; and leaf area, diversity, dominance, and productivity for forest stands (Smith 1990). Odum (1985) has outlined the general trends expected in stressed ecosystems in terms of energetics (e.g., increased respiration/production ratio and low efficiency of converting energy to organic structure), nutrient cycling (e.g., increased nutrient losses), and community structure (e.g., proportion of opportunistic or "weedy" species increases, decreased size and life span of organisms). Other trends in stressed ecosystems include decreased resource use efficiency, increased parasitism and decreased mutualism, ecosystems that become more open as internal cycling is reduced, and reversed successional trends (Odum 1985). Schaeffer and others (1988) acknowledged that some pathologies of ecosystems are known, such as increased horizontal transport of nutrients, increased production/biomass ratio, and decreased diversity. Species diversity of an ecosystem can also increase in response to stress if original diversity is low (Odum 1985). Schaeffer and others (1988) defined a diseased ecosystem as one in which the effects of illness are profound. These effects or indicators of a diseased ecosystem include changes to: standing vegetative biomass, gross or net primary energy production, relative amounts of energy flow to grazing and decomposer food chains, mineral macronutrient stocks, and changes to both the mechanisms of and capacity for, damping undesirable oscillations. Diseased ecosystems may also include decreased numbers of native species, and overall regressive succession.

Indicator Categories

The Environmental Monitoring and Assessment Program (EMAP) of the United States Environmental Protection Agency (EPA) recognizes four broad categories of environmental indicators for natural resources: response indicators, exposure indicators, habitat indicators, and Stressor indicators.

Response Indicators are the primary gauge of ecological condition, and may consist of indicators at the level of organisms, populations, communities, or ecosystem characteristics. Examples of response indicators for forests include tree growth efficiency, visual symptoms of foliar damage, nitrogen export, abundance and species composition of understory vegetation, or animal demographics.

Exposure indicators are measures of organism, population or ecosystem exposure to chemicals, nutrients, acidity, heat or physical stress. Examples of exposure indicators include visual symptoms of foliar damage (which may also be a response indicator), nutrients or chemical contaminants in tree foliage (or in mosses and lichens), and biomarkers (e.g., inducible enzyme activity in response to pollution exposure).

Habitat indicators represent conditions that are necessary to support an organism, population or community. Abundance and density of key physical features (i.e. snags, cliffs, seeps, talus slopes), extent and spatial pattern of vegetation cover, and vertical layers of vegetation, are examples of habitat indicators. Exposure indicators and habitat indicators are used by EMAP to identify and quantify changes in exposure and physical habitat that are associated with changes in response indicators.

Stressor Indicators reflect natural processes, environmental hazards or management actions that stress an ecosystem. Examples of stressor indicators include measures of pollutant emissions, number of permits for construction activity, land use practices, climate fluctuations or conditions, pest and disease outbreaks, or silvicultural treatments.

Criteria for Indicator Selection

Hunsaker (1993), Hunsaker and Carpenter (1990), and Schaeffer and others (1988) have outlined the following desirable characteristics of indicators for an environmental and monitoring and assessment program:

- Correlation with changes in processes or other unmeasured components
- Appropriate for regional monitoring
- Integration of effects over time and space
- Low natural variability
- Unambiguously related to forest health and sustainability, a relevant exposure or habitat variable, or stressor
- Related to the overall structure and function of ecosystems
- One of several indicators that collectively represents a set of environmental values, but is not redundant
- Responsive to stressors of concern for management strategies
- A standard method of measurement and low measurement error
- A historical data base or accessible data for development of a data base
- Cost effective (low cost/high information value)
- Reflects knowledge of "normal" changes, for example, due to succession or other sequential changes
- Defined ranges of "normal" values (Schaeffer and others 1988)
- A sufficiently high signal-to-noise ratio (Kelly and Harwell 1990)

Examples of Response Indicators of Forest Sustainability

Some indicators that have been implemented or considered to varying degrees (Hunsaker and Carpenter 1990) include: litter chemistry dynamics, microbial biomass and respiration in soils, leaf

spectral reflectance, remote sensing, nutrient indices such as DRIS (Diagnosis and Recommendation Integrated System) (Riiters and others 1992), amino acids and nutrient ratios in foliage (McLaughlin and others 1994), stand structure (composition, diversity, dominance), animal demographics, and bioassays (e.g., mosses and lichens). Although more research is needed to refine existing indicators, and to develop new ones, four potential indicators of forest health and sustainability have been assessed for their accuracy and effectiveness.

Tree growth efficiency

Tree growth efficiency reflects the ability of trees to maintain a healthy and productive presence in an ecosystem. Tree growth efficiency is also related to sustainability because higher growth efficiency is associated with higher resistance to insect attack (Mitchell and others 1983). The use of a growth efficiency indicator is based on carbon allocation patterns in trees. Environmental stresses that alter carbon allocation are manifested first in reduced stem-wood growth and reduced production of protective chemicals. Thus, stem-wood growth is used as the indicator (Hunsaker and Carpenter 1990).

Growth efficiency is estimated as stem-wood volume growth ($m^3 ha^{-1} yr^{-1}$) or biomass growth ($kg\ ha^{-1} yr^{-1}$) divided by capacity for growth. The denominator can be one of several indices of the amount of light absorbed by the overstory trees (e.g. leaf area index (LAI), or fraction of photosynthetically active radiation absorbed by the canopy (APAR). For application as a response indicator, threshold values for subnominal growth efficiency will need to be developed, possibly from the literature, previous data, and further research and testing.

Some have maintained that the numerator and denominator should be separate indicators, because if both the numerator and denominator decrease similarly, the growth efficiency value will remain constant even though productivity and sustainability have changed (Hunsaker and Carpenter 1990). Furthermore, interpretation of growth efficiency indicators should be done in conjunction with information on species composition, age, stand density, etc. Measurements of stem-wood and foliage measurements should be taken after the period of rapid changes from spring to mid-summer. The recommended frequency for data collection is 10 years (Hunsaker and Carpenter 1990). Stem-wood volume can be determined by standard techniques (Husch and others 1972). LAI can be estimated from remotely sensed data, and LAI or APAR can be obtained using hand-held devices in the field (Hunsaker and Carpenter 1990).

The major problems with the stem-wood as an indicator include obtaining sufficiently accurate volume or biomass measurements with the standard procedures. More accurate, although more expensive methods may need to be used. The indirect methods of estimating LAI and APAR also have their limitations. The most appropriate method will depend on stand composition, stand density, terrain characteristics, and related factors.

Visual symptoms of foliar damage

Measures of visual symptoms provide a response indicator for the environmental values of productivity and aesthetics, and they may indicate exposure or habitat stresses affecting forest condition. Following the protocols for visual surveys used in international programs will enable interspecific comparisons and greater relevance to studies in other regions of the world (Hunsaker and Carpenter 1990). "Indicator plant" observations may be effectively used to signal exposure of the forest to specific pollutants. In monitoring programs, native indicator plants are considered as response indicators since they are actual components of the forest ecosystem, and as exposure indicators because they indicate possible damage to other species (Hunsaker and Carpenter 1990). Biomonitor plants with known sensitivity and symptom development with exposure to particular pollutants can also be used as exposure indicators (Krupa and others 1993).

Core measurements of visual symptoms frequently made are crown density, crown transparency (measures of defoliation), height to live crown ratio, crown class, discoloration, crown dieback, needle length and retention, and identified insects and pathogens. If destructive samples are needed they should be collected at nearby sites away from the permanent monitoring plots. Root

samples can be cultured for identification of pathogens. The primary problem with visual injury indicators is the standardization of measurement and assessment methods, and training of crew members to determine the subjective estimates of crown condition consistently within a 10% range.

Nitrogen export

Nitrogen export from a forest ecosystem in the form of nitrate (NO_3^-) has potential as a useful response indicator because it provides a net watershed level response, and an integrative measure of the many processes of nitrogen cycling within a watershed. Losses of nitrogen from disturbed ecosystems are usually much greater than for other nutrients. Although disturbances do not always result in altered NO_3^- losses, changes in NO_3^- export does provide strong evidence of disturbance within the ecosystem. Chance occurrences such as wildfire, insect defoliation and animal foraging can also affect nitrate concentrations in stream water (Hunsaker and Carpenter 1990).

To implement this indicator, samples of surface water runoff or ground water are obtained and analyzed for NO_3^- concentration by standard laboratory procedures. The episodic nature of nitrogen export could be a drawback of this indicator, making it difficult to select an optimal sampling window. However, NO_3^- concentrations tend to be highest during snowmelt in the spring, or when plant and microbial demand for nitrogen is lowest. Older highly mature stands may also be less retentive for NO_3^- than younger more vigorously growing stands.

Soil productivity index

Soil productivity can be defined as the capacity of a given volume of soil to produce a vegetative response under a specified system of management. Initial measurements of key soil productivity variables are used to establish baseline levels and ratios among physical, chemical and biological soil constituents. This baseline soil characterization is then related to nominal and subnominal forest condition as estimated by response indicators (Hunsaker and Carpenter 1990). Periodic remeasurement of these values every 4 to 6 years can be used to assess trends. Most commonly, soil parameters of interest include specific soil nutrients, toxic substances, erodibility factors, soil structural characteristics, parent materials, and ancillary data such as soil moisture supply (Palmer Drought Index, Hunsaker and Carpenter 1990).

Soil productivity data provide interpretive data that is not available through foliar chemical analysis because plants may compensate for limited soil nutrients and moisture. Forest productivity can be affected by chronic or acute deficiencies of essential soil nutrients. Soil characterization and sampling should be done concurrently with the foliar sampling and tree measurements at a given plot. Because of the significant spatial variability that can occur within a single plot, a composite sample collection design may be in order.

SUMMARY

Current trends in economic development to satisfy societal needs and desires is at the core of our environmental problems. Until recently the balance was in favor of an economic development paradigm which did not adequately consider the negative impacts of the economic activities on the natural environment. This choice currently is best exemplified by the rapid deterioration of the tropical regions of the world. A new economic development paradigm is needed by which the sustainability of the natural environment is guaranteed.

Sustainability can be achieved by monitoring carefully selected indicators of ecosystem health, thus ensuring that ecosystem management and economic activity do not cause significant deterioration of ecosystem health and functioning. However, the cost of monitoring ecosystems health with indicators must not be excessive, or implementation of ecosystem health monitoring programs will be very difficult in many countries of the world with great environmental problems and little financial resources.

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Methods for monitoring sustainability

Andrew J. R. Gillespie[1]

ABSTRACT.—Sustainable management requires reliable information. Information can come from a variety of sources. Monitoring consists of a long term, periodic collection of information which helps determine the current status of a system as well as the changes which occur over time. This information feeds back into the management planning process, allowing corrections to maintain the system in a sustainable state. This paper discusses various aspects of designing a system to monitor sustainability of forest ecosystems including defining monitoring objectives and measurements, designing the sampling system, conducting quality assurance activities, and continuous improvement of the monitoring system over time.

INTRODUCTION

There is increasing recognition that the most important resource with which land managers deal with is not forest, water, or even people. The most important resource is information. In the absence of information, all of our planning amounts to nothing more than guesswork, with results ranging from very good to very poor. Given the correct information, management becomes a rational process free of frequent nasty surprises. Sustainable management of a system depends on reaching a state where we have sufficient information about the system to select, in perpetuity, management options which will maintain the system in a desired, sustainable state. This is a tremendous challenge.

There are many ways to gather information. One of the most traditional and reliable is through experience. A land manager may spend a career on a given piece of land, trying different activities, experiencing successes and failures, and making mental associations between cause and effect. Over time, this experience is transformed into a set of rules which the manager keeps in his head. The manager may be able to commit some of this information to paper for future generations of land managers to follow, or the experienced manager may have the opportunity to mentor younger managers and impart the information directly.

A second way of gathering information is to actively seek out information, as an end in itself rather than as a means to an end. This has traditionally been the domain of natural resource research organizations such as the USDA Forest Service Research and Mexican Instituto Nacional de Investigaciones Forestales y Agropecurias. Such investigations take many forms from designed experiments to broader based monitoring and inventory efforts. This paper focuses on developing monitoring systems.

This paper is organized into two general parts. The first part discusses some of the needs for information in sustainable management, and outlines various strategies by which these information needs may be met. In this context, the meaning of 'monitoring' is used in the broadest sense of 'gathering information about a system'. The second part of the paper deals with some specific consideration for developing a process suitable for monitoring sustainability of a natural resource management system.

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THE ROLE OF MONITORING IN SUSTAINABLE MANAGEMENT

In the US there is currently a philosophy called Adaptive Management which is capturing the interests of resource managers (Lee, 1993). Adaptive Management is the scientific method applied to management activities. Under Adaptive Management, you plan and implement an activity, monitor the implementation and results, assess the outcome, adjust your working hypotheses, and feed the information back into the management planning process:

In this model, monitoring is used both to establish a baseline of the status of current conditions within the system, and to track changes in the status of the system over time. The monitoring should be broad enough to include some areas which are not treated in any way, to act as 'control' sites. This allows one to generate cause-and-effect hypotheses about changes in the behavior of the system as a result of management practices, and to test these hypotheses using appropriate designed experiments.

DEFINITIONS OF SUSTAINABILITY AND IMPLICATIONS FOR MONITORING

Clear definitions of what it is we are trying to measure are a prerequisite to a successful monitoring system. In the context of natural resource management, 'sustainable' is generally defined to imply 'maintaining the environmental system in such a state that the system is able to function in perpetuity'. This does not necessarily imply that the status or outputs of the ecosystem - water, timber, food, recreation, aesthetics, etc. - will remain constant forever. However, 'sustainable' generally implies that no one output of the system will be utilized to the extent that the long term productivity of the ecosystem will degrade. The implication for monitoring is that monitoring for sustainability requires measurements of many different resources, not just one or two resources of interest. It also implies a long-term perspective, rather than focus solely on short term changes.

Increasingly managers are faced with the demand to create management systems which are economically sustainable as well as ecologically sustainable. Many people derive their livelihoods from management or use of forested ecosystems. To such people, short term economic considerations are often more important than long term ecologic considerations. In the larger picture, both sets of considerations are important. The implication is that monitoring for sustainability requires measurement of social and economic parameters, and can not be limited solely to ecological parameters.

The issue of sustainability depends very much on spatial scale. With modern advances in communication, trade, and transportation, the world is increasingly interconnected. Changes in one ecosystem (e.g. frost in Brazil) now impact other ecosystems (e.g. increased coffee prices in the US) in a way that they never did before. Local actions have global implications, and vice versa. The implications for monitoring are (1) the need to consider multiple levels of scale when monitoring management activities, (2) the necessity of sharing information across administrative and political boundaries through collaborative research and bilateral symposia such as the present one.

DEVELOPMENT OF A MONITORING SYSTEM

Like Adaptive Management, the development of a good monitoring system is often an iterative process, rather than a linear process. As you plan and implement monitoring, you lean more about the system and are able to increase monitoring efficiency by modifying the monitoring system. In each iteration, there are several key steps: development of monitoring criteria, relating those criteria

to measurable indicators, selecting a sampling design, implementing the monitoring, conducting quality assurance assessments, improving the monitoring system, and reporting the results of the monitoring. The following discussion briefly considers each of these activities.

DEFINING THE POPULATION OF INTEREST

One of the first things required is a definition of the population of interest, e.g. the ecosystem whose sustainability you wish to monitor. The boundaries may be arbitrary, but they must be clearly stated in order to define the potential set of sample elements available to monitoring. The population may be stratified, for example several major forest types existing within a given forest. However, realize that for each stratum for which you wish to make a statement, you need to collect a minimal amount of information. Too many strata may result in a very large and expensive sample size.

DEVELOPMENT OF MONITORING OBJECTIVES

The next task in designing a monitoring system is to identify exactly what it is that you want to make statements about: that is, what are the sampling or monitoring objectives. These objectives are typically formulated broadly, then refined into attributes which may be quantified through field measurements. 'Sustainability' is an example of a monitoring objective formulated at its broadest level. There are many other potential monitoring objectives, e.g. productivity, aesthetics, spatial extent, and diversity.

DEVELOPMENT OF INDICATORS FOR THE MONITORING OBJECTIVES

Once the monitoring objectives are determined, the next step is to develop a list of indicators which can be related to the monitoring objective. The distinction between a monitoring objective and an indicator is that the indicator must be quantifiable, either through direct measurements or via an aggregation of direct measurements. A monitoring objective is typically addressed through several indicators. For example, using 'sustainability' as our monitoring objective, potential indicators of sustainability might be species diversity, soil nutrient status, net primary productivity, stream water quality, and population levels of a key indicator species.

It is unlikely that any single indicator will suffice to describe completely the status of the ecosystem with respect to sustainability. However, by monitoring several key different ecosystem attributes (e.g. vegetation, animal populations, soil and water quality), it is more likely that changes in factors affecting sustainability will be noticed if they occur.

Once a list of indicators is selected, the next step is to determine what measurements are required to quantify the indicators. Some indicators (e.g. soil organic matter) may be directly measurable through a sampling and laboratory analytical procedure. Other indicators may not be practical or possible to measure directly, but may be estimable through indirect means. For example, measuring biomass increment of trees might be done by measuring tree diameters and heights, then using a regression equation to estimate biomass.

There needs to be some objective means of assessing how well the indicator performs in terms of quantifying the monitoring objective. The following seven criteria are being used by the US National Forest Health Monitoring (FHM) program to assess the effectiveness of proposed monitoring indicators (Lewis and Conkling, 1994).

Interpretability. The indicator needs to be clearly and simply related to the sampling objective. In statistical terms, there ought to be a meaningful correlation between changes in the value of the indicator and changes reflected in the status of the associated monitoring objective. Ideally there will be a range of indicator values associated with 'good' and 'poor' status of the monitoring objective. This range of values may come from previous studies, past experience, expert opinion, or even pubic opinion. There will always be a certain amount of arbitrariness associated with the interpretation of indicators. Nonetheless it is critical to establish these threshold levels initially; they can always be adjusted later if appropriate.

Measurement period stability. In a field monitoring effort, data will typically be collected during some measurement period, e.g. June 15- August 30. Ideally the value of an indicator should remain constant over the entire measurement period, so that measurements taken at the start of the period may be treated the same as measurements taken at the end of the measurement period. If an indicator does change in value over the measurement period, the data may still be useful if the change can be modeled and adjusted prior to analysis. If the mean of the measurement remains constant but there is an associated variation over the measurement period, then the variation over the period will increase the uncertainty in the final estimate and will decrease the power to detect change in the measurement over time. If the mean of the measurement changes over the measurement period (for example, foliage cover decreases as growing season closes), then inter-period change may be confused with between-period change in some arbitrary fashion depending on the order in which sample units are sampled. Measurement period stability for an indicator is best assessed through a designed experiment which quantifies the variance component associated with measurement period instability. The FHM program uses an arbitrary level of 10% as the maximum acceptable percent variation due to measurement period instability.

Signal-to-noise ratio. This refers to the magnitude of variation in a measurement. As the amount of variation (noise) in a measurement increases, the ability to detect change in the mean value of the measurement (signal) decreases. Indicators with large variance components will require either more time or larger sample sizes for change detection than will indicators with lower variance components. Signal-to-noise is determined by an analysis of variance components from data collected over time. A typical threshold value for determination of acceptable signal-to-noise ratios consists of stating the magnitude of change which one wants to detect given a certain sized sample and level of statistical power.

Population responsiveness. This refers to the ability of an indicator to reflect changes across the whole region or population of interest. It is assumed that the relationship between indicators and the associated monitoring objective are consistent across the whole population, and that changes in the objective criteria (e.g. sustainability) will result in consistent changes in the indicator throughout the population of interest. In cases where indicators do not behave consistently across the entire population, it may be appropriate to post stratify the population of interest into subpopulations in which the indicator does behave consistently. Population responsiveness can be addressed through use of spatial statistical analyses, to look for patterns in means or variances associated with other spatial criteria, e.g. forest type or topography.

Environmental impact. Ground based monitoring implies repeated measurements of indicators over time. It is possible to use completely independent samples at each time period; however, the variation between samples would then serve as 'noise' to hide whatever changes had occurred in the indicators. It is more common to perform repeated measurements on the same sample elements using permanent plots. If this is the case, then it is critical that the measurements and the measurement process be monitored to insure that the process of monitoring does not itself change the attributes being monitored. Logistic elements such as crew training, crew size, and frequency of visit determine the degree of environmental impact. Biotic conditions such as moisture, soil type, and vegetation at the plot site also determine environmental impact. Environmental impact can be minimized by careful planning of fieldwork, elimination of destructive sampling from the immediate plot area, and training crews to be sensitive to impacts. However, assessment of the environmental impacts of measurements requires a designed study with controls.

Logistic feasibility. The logistic feasibility of a measurement depends on many things including the level and training of crews, the type of equipment available, and the amount of time available to complete the fieldwork. Measurements need to match the abilities of field crew. For example, a botanical survey may not be possible if there are no botanists available to serve on crews. Crews need to be equipped appropriately, relative to the level of precision required in the measurements. The time involved in measurements is also important, particularly if the time involved in getting to

and from the measurement site is large (say 20% or more) relative to the time involved in collecting measurements.

Cost effectiveness. The value of the information returned from an indicator needs to be considered relative to the cost of collecting the information. The cost of collecting the information depends on the time, people, and equipment required to collect the indicator. Crews will typically be measuring several indicators at each site, so the addition of an indicator may have significant cost impacts on a crew, for example if it requires a crew to visit a plot a second time.

SAMPLING DESIGN

Anecdotal information gleaned from casual, unplanned observation can be a vital basis for generating hypotheses and ideas about ecosystems. However, a monitoring system intended to support long term information collection needs a formal, statistical basis in order to protect against observer bias and to minimize the risks that changes in the system will go undetected. This statistical basis involves many decisions which are commonly referred to collectively as the 'sampling design'.

A suitable sampling design can only be selected after several key decisions are made. The sampling objectives must be clearly defined in terms of what is going to be measured. Sampling objectives may relate to ecological items (e.g. soil nutrient status, water chemistry, plant species diversity, acres harvested) or to socioeconomic items (e.g. revenues from forest products, usage rates by local families, economic rates of return on forest investments). The population of interest must be clearly defined. Ideally there should be a statement of the minimal level of precision desired in estimates, e.g. + or - 10% at 95% confidence.

Once these preliminary criteria are defined, there are several other key issues which help determine the final sampling design. These include scale, or the utility of multistage sampling; the required periodicity of sampling; and the appropriateness of an inventory based system vs. a designed experiment.

The Need for a Probability Based Sample. A probability based sample is a sample selected at random from a population where the probability of selection for each possible sample is known. This is different from a sample selected purposively, where the person making the selection decides whether or not to include the sample element based on some personal (non-random) judgement.

The advantage of a probability based sample is that there is then a large body of sampling theory available to make inferences about the accuracy and precision of estimates based on the sample. There is no way to make similar inferences for non-probability based samples.

A probability based sample need not be terribly complicated. The simplest way to select a sample with known probability is to use equal selection probabilities, selecting each sample element (tree, plot, watershed) with equal probability. More complicated sampling methods may be used to increase sampling efficiency (e.g. the use of a prism to select sample trees with probability proportional to size). However, when setting up a monitoring scheme for something as complex as sustainability, which may involve a multitude of measurements, it is unlikely that any single weighting scheme will be optimal for all measurements, so an equal probability sample is generally a reasonable choice.

Scale. An ecosystem can be studied at an infinite number of scales from the landscape to the organism. Clearly it is impossible to engage in monitoring at all possible scales; typically monitoring is done on a finite, usually small number of levels. For example, satellite imagery or aerial photos can be used to monitor changes in extent of various forest types or land uses in an area. This monitoring can be done on a permanent basis by georeferencing the imagery and looking at the same area over time. The imagery can also be used to stratify the population or area of interest, and a second level of sampling (e.g. ground visits to permanent plots) can be overlaid to look at different indicators.

Such a multistage sampling system is valuable because it allows measurement of indicators at varying spatial scales, which increases the likelihood of detecting ecosystem changes which may be observable at one level before observable at

other levels. It is generally straightforward to design a multistage probability based sample such that the various stages can be statistically linked, enabling inferences which combine information from two or more of the sampling stages.

Systematic vs. Random Location of Sample Points. Sample sites may be located across a population in a systematic fashion (e.g. by overlaying a grid), or randomly by selecting sample sites at random from the population of sample sites. Most monitoring systems favor systematic grids because of the desire for even spatial coverage and for simplicity in sample location. As long as the population of interest is free of spatial patterns which coincide with the sampling frame, experience has shown that systematic samples often give more precise results than simple random samples (Cochran, 1977). A systematic sample may be risky if the spacing or orientation of the grid corresponds to some spatial feature in the population of interest in some way, for example if the grid is aligned along a major river or mountain ridge. If used, a grid should be initiated with a random starting point and a random orientation, and results should be analyzed spatially for unexpected spatial trends.

Frequency of Measurement. The timing of visits depends on the rate of change and periodicity in the indicators being measured. Annual visits may be required in cases where indicators change annually, e.g. many measurements of tree crown conditions or fruit productivity. Less frequent visits are appropriate for indicators which change less rapidly, e.g. tree diameter. Some indicators need to be monitored continuously, e.g. precipitation or air pollution levels. The frequency of visit needs to be balanced against the cost effectiveness (is the information worth the cost of collection), as well as the potential environmental impacts of additional visits. A monitoring design may incorporate several measurement types, for example annual visits to collect understory vegetation data plus 4 year visits to collect tree growth and mortality data. Monitoring of ecosystem sustainability will involve measurement of indicators which change rapidly (e.g. water chemistry, crown condition) as well as indicators which change more slowly (tree species diversity, biomass accumulation), which implies a need for several different measurement types and measurement periods.

Inventory vs. Designed Experiments. An inventory is an accounting of what exists in some population of interest. An inventory approach to monitoring will describe the status and change of the system over time, but will not by itself be sufficient to test hypotheses about cause and effect, e.g. 'what is the long term effect of clearcutting on ecosystem sustainability?'. The inventory approach is what most people commonly think of as 'monitoring'.

Cause and effect hypotheses can be tested using a designed experiment approach. A designed experiment typically involves a treatment (e.g. silvicultural prescription, herbicides, genetically superior planting stock) whose effect we wish to measure. The treatment is applied to a random sample of units, and another random sample of units are left untreated as a control. Assuming that the treatments were assigned to the sample units randomly, and that the sample units are a random sample from some population of similar units, then differences in the response (e.g. growth, species diversity, soil chemistry) between the control and treatment can be tested for statistical significance.

A common example in forestry for testing hypotheses about sustainability of silvicultural treatments are systems of long term permanent growth plots which many managers set up and maintain over time. It is important to recognize that these plot systems are designed experiments, and must be treated as such in order to support statistically defensible hypotheses testing. In particular, it is critical to assign treatments at random to sample areas, at the start of the program; to have true replication, rather than a single plot for each treatment; and to include untreated sample units as controls.

Experimental design is a well-researched field. If the rules are followed, experiments can be powerful tools for monitoring sustainability over time. A holistic monitoring system for addressing a concept as broad as 'sustainability' will likely need to incorporate both inventory-based monitoring as well as experiment-based monitoring activities.

QUALITY ASSURANCE

Quality assurance refers to a set of activities which are implemented in order to build confidence in the accuracy, precision, representativeness, completeness, and comparability of collected data. There is a large body of literature dealing with quality assurance, but most of the literature deals with manufacturing or laboratory processes. Nonetheless, the principles of quality assurance can be applied to ecological and economic monitoring as well, and many management agencies are attempting to do so (e.g. the USDA Forest Service Northeastern Station 1994). Following are some basic Quality Assurance principals which can be incorporated into data collection.

Establishment of Measurement Quality Objectives. Anytime a measurement is conducted, we need to specify the desired quality of the measurement. The desired level of quality is defined chiefly by the use to which the data will be put. A typical measurement quality objective consists of a maximum allowable error in a measurement which is acceptable a certain proportion of the time. Measurement quality objectives should be established for all measurements, whether quantitative or qualitative. The error may be expressed in absolute units, in terms of percent, or in terms of standard deviations. Some examples:

Tree diameter	+ or - 2 cm, 95% of the time
Timber volume cut	+ or - 10%, 95% of the time
Crown class	+ or - 1 class, 90% of the time
Species name	No error, 99% of the time

Establishing these objectives serves several purposes. The objectives allow data users to know how much error exists in the measurements, which is useful knowledge when conducting analyses. The objectives serve as targets for training sessions, objective measures of whether or not crews have been adequately trained. The objectives can also be used to determine whether or not field crews are conducting the measurements in the proper fashion, as well as whether or not the measurement methods are able to achieve the target data quality. If the measurement procedures are not able to satisfy the measurement objective, there are two choices: relax the objective, allowing greater amounts of error, or modify the measurement procedures (better training, better equipment) to meet the target measurement quality.

Documentation. Clear written documentation of all measurement methods are required. These materials serve as training and reference materials for crews, as well as documentation for future managers and data analysts who will be working with the data generated by the monitoring system. Documentation may need to be updated periodically to reflect changes in the monitoring program. Documentation of measurement methods is one of the most often neglected aspects of monitoring, and lack of adequate documentation is one of the most frustrating challenges facing those who rely on monitoring data.

Training. Training of those collecting the data is a critical part of the quality assurance process. Data collectors have the greatest impact on data quality, affecting the quality of all subsequent analyses and assessments which use the data. Good training depends on well defined and documented measurement procedures, as well as experience and expertise on the part of the trainer in training techniques. The best training program is developed jointly by experts in the measurement processes and experts in education methods. Training should end with a certification test to make sure that all potential data collectors can meet measurement quality objectives for all measurements.

Audits and Resampling. Training does not stop with the initial training session. After a week or two on the job, most data collectors will benefit from a training audit, which is a visit by an expert in the measurements. The expert watches the data collectors in action, answers questions, and offers advice and coaching to help the data collectors improve their technique.

After the crews are more experienced, remeasurement audits may be conducted. These are independent remeasurements of the same sample elements by an expert crew, in the absence of the original crew who first collected the measurements. The objective of the remeasurements are to establish between-crew variability, to identify crews or measurements which are not conforming to stated measurement quality objectives, and to collect the data needed to show that measurement quality objectives are being satisfied. Remeasurement audits are typically accomplished by randomly selecting audit plots from the list of

already-completed plots, usually stratified by crew so that each field crew is audited but does not know in advance which plot will be audited.

Analysis of Quality Assurance Data. The data collected during resampling audits are valuable for a variety of purposes. Comparisons between the expert crew and standard crews will identify any crews where data quality is substandard, implying the need for more training. If many crews exhibit variation with the expert crew on some measurement, it might indicate a problem in the training program or in the measurement itself. Statistical analysis of the data from the resampling audits can be used to estimate means and confidence intervals of the deviations between repeated measures of the same sample elements, which can then be compared to the established measurement quality objective. Information from this analysis is invaluable in improving the measurement and training process over time, leading to continuous improvement in the monitoring system.

INFORMATION MANAGEMENT, ANALYSIS, AND REPORTING

Information management, analysis, and reporting systems are often overlooked or neglected until data start flowing in to the office; then an ad hoc system is patched together using whatever methods and capabilities happen to be available. Over time, the ad hoc system is 'fixed' in a variety of ways until finally it collapses under its own weight and must be redesigned, at a great cost in terms of wasted effort and the time loss while the new system is implemented.

It is much better to plan and develop an information management, analysis, and reporting system as a part of the monitoring system. The system need not rely on state-of-the-art computer databases and portable data recorders; simpler systems using data collected on paper and entered into flat ASCII files may well be most appropriate for the needs of the monitoring system. The important item is to have an Information Needs Assessment (INA) before monitoring begins, so that the information management systems may develop along with, not in response to, the data collection systems. Conducting an INA can be simple or complex depending on the degree of complexity proposed in the monitoring system. Expertise in information management needs to be combined with expertise in the measurements being collected as well as expertise in the analysis of the data to develop an information system to serve long term program needs.

SUSTAINING MONITORING IN THE LONG RUN

Monitoring is an activity that needs to be repeated over time in order to become most valuable. The costs of establishing a monitoring system are often greater than the cost of sustaining the system, but not always by much. Monitoring can be a relatively expensive process, which unfortunately makes it an attractive target when budgets are tight. It is imperative that management recognize both the present value of the information being collected as well as the future value of maintaining the monitoring effort.

There are several activities important to maintaining monitoring over time. The most important is adequate planning. Planning must address all key areas: training, logistics, quality assurance activities, information management systems, assessment and reporting. Written plans are needed for all activities, so that all participants know what is expected at what time. Ideally plans ought to be reviewed by people outside the monitoring program, to avoid excessive 'inbreeding'.

Budgeting is also crucial for monitoring. It is important not to spend all available resources on data collection, and to leave resources for planning, quality assurance activities, information management, analysis, and reporting.

The monitoring system needs to be subjected to continuous improvement. Periodically, information gathered from quality assurance activities, peer reviewers, and especially from the users of the information generated by monitoring can be used to make improvements in the design, implementation, or reporting of monitoring information.

Finally, there will be research needs associated with the monitoring system. For example, monitoring information may generate a cause-effect hypotheses regarding some management practice and a resulting ecological impact. There needs to be some way to bring such research needs to the

attention of appropriate researchers, either within the program or not, so that these research questions may be addressed in a timely manner.

SUMMARY: MONITORING SUSTAINABILITY

Development of a system to monitor forest ecosystem sustainability over the long term should consider the following steps:

1 Define ecosystem(s) of interest, monitoring objectives, and associated indicators of sustainability.

2 Select appropriate sampling design(s) to address objectives.

3 Plan the fieldwork:

- Develop measurement quality objectives, documentation of techniques, training plans
- Decide what quality assurance activities will be implemented
- Develop the information management, analysis, and reporting system
- Acquire whatever equipment and materials needed to implement measurements

4 Recruit and train data collectors.

5 Implement the fieldwork, including quality assurance activities.

6 Analyze quality assurance data, make necessary changes in sampling design, measurement methodology, training procedures, or personnel.

7 Go to step (3) for the next iteration of the monitoring activity.

Note that this model corresponds closely to the adaptive management model described at the start of this paper: plan, act, monitor, evaluate, and repeat. Monitoring is a scientific activity, and as such is amenable to the scientific method.

No amount of a priori experience will anticipate all potential challenges in the initial implementation of a monitoring system. It is best to think of the initial implementation as a pilot implementation, with the first 'real' implementation occurring after digesting the experience gained in the initial implementation. The initial experience will be a valuable learning experience in itself, and future iterations will only compound the value of the information being gathered. In time, monitoring will lead to the database necessary to support ecological and economically sustainable forest ecosystem management.

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Forest management methods for sustainable evaluation: An overview for Mexico

Gerardo Segura[1]

Abstract.—Even though forest resources occupy much of the Mexican territory and represent an invaluable ecological and economical resource, forests have not been conserved or managed sustainably. Currently, Mexico has one of the largest deforestation rates and its forest sector is undergoing a severe crisis in which production has declined as much as 30%. Imports have increased similarly.

The reason of this crisis is partially related to the lack of competition of Mexican forest products in international markets within the more open economy generated by treaties like GATT and NAFTA. Given this situation, and the fact that more than 80% of Mexico's forest lands are owned by some of the poorest rural landowners and are under one form or another of communal ownership, I argue that before more sustainable forest management practices can be achieved, and specific criteria and methods to evaluate it can be designed and implemented, it is essential that certain minimal conditions are met to assure that forest management practices are viable not only from an ecological but also from a social and economic perspective.

I review these minimal conditions based on the three conventional criteria of equity, natural capital, and efficiency. These are analyzed from a historical perspective to find out why these conditions have not been met in rural areas of Mexico. Severe equity problems have been generated by inappropriate government forest policies that have either been nonexistent or biased in favor of industry and not of landowners. Problems in the definition or vagueness in assigning property rights, and granting forest concessions to timber companies that have been responsible for extensive timber mining activities, are associated with these policies. Forest concessions, which have caused severe degradation of forest resources, have led to important reductions and deterioration of the natural capital of large areas of forested lands.

A lack of natural capital has also been a problem in many tropical forest areas where only a small percentage of the available timber volume is commercially valuable. Finally, not allowing forest products to be sold competitively both locally and internationally has also been a common problem in most forest areas. Inefficiencies have been detected in all aspects of the productive cycle including silvicultural practices as well as transportation, industrialization, and commercialization of forest products. These inefficiencies have been mainly related to a severe lack technical assistance and infrastructure.

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Management applications for sustainability

Hugo Manzanilla[1]

Abstract.—It is not possible to reach the sustainability of natural resources if sustainability's close relationship with the human race is not understood. Throughout time, humans have survived by using natural resources. Forests can be kept in a sustainable state without human presence, but when humans use them it is necessary to assure forest sustainability throughout time and space. When society lives in contradiction with sustainability, natural resources become more scarce. Products derived from natural resources are many and complex; the system that produces them is an integration of primary products, added value products, energy, food, medicine, and ecological, cultural, and recreational values.

To reach sustainability of the above-mentioned products and values, humans must consider themselves as the owner and user of all of them. Humans must acknowledge the limits and brevity of human life, scientific information, and the long periods of time in which natural resources require to develop. It is important to recognize that good management of natural resources can support poorly developed areas and can satisfy human needs without risking natural resources for future generations. Our challenge is to teach all children love and respect for natural resources and to use them properly.

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Management applications for sustainable ecosystems: A case study in the Klamath National Forest

Barbara Holder[1] and Joyce Andersen[2]

Abstract.—For over two decades there has been growing controversy over managing old growth forests on Federal lands in the United States. Changing social values, legislation and litigation has forced greater attention to manage for sustained ecosystems. In 1992, the Forest Service established a policy of "ecosystem management." Managing sustainable ecosystems means retaining biological diversity in terms of composition, structure, processes, and interrelated functions while meeting peoples needs. Partnerships between local communities, research and management are emerging through adaptive management applications. This paper describes a process and management applications for sustaining ecological systems.

INTRODUCTION

"*Sustainable development is not a goal...Rather it is more like freedom or justice, a direction in which we strive*" (Lee 1993).

In the last decade, the northern spotted owl became the focus of a debate over how federal lands in the Pacific Northwest should be managed. This ongoing controversy resulted in lawsuits, court rulings, appeals and protests. So President Clinton commissioned an interagency scientific team to develop alternatives for managing forests within the owls range. The President then directed his cabinet to craft a balanced, comprehensive and long-term management policy for over 24 million acres of public land. Management direction was issued on April 13, 1994.

This management direction is a comprehensive ecosystem management strategy, much of it aimed at restoring and maintaining watershed health. Watershed analysis is required to develop a scientifically based understanding of an ecosystem. The analysis focuses on key issues, existing and desired conditions, key ecological processes, restoration opportunities and major planning and coordination requirements. Watershed analysis will guide future monitoring and inventory by disclosing data gaps. Since 1991, the Klamath National Forest has been developing a methodology to implement ecosystem management. We have designed a process to conduct watershed analysis and analyze ecologicalprocesses and interactions. This process has resulted in three significant changes from how we have managed in the past. First, the scale of analysis is expanded to fifth order watersheds, rather than aggregations of selected stands. Second, management objectives are designed to sustain ecological processes that benefit ecological systems instead of individual resource targets such as timber harvest. Third, the purpose and need for individual projects directly relates to sustaining ecological processes and functions, such as underburning, fish habitat improvements or vegetation management.

This paper focuses on a direction to adaptively manage for sustainable ecosystems. Watershed analysis is the process we use to guide resource

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decision making and drive project development. Anticipated products from this analysis include an understanding about the ecological structures, functions, processes and interrelationships.

WATERSHED ANALYSIS

"We assume that management designed to reproduce key natural processes is likely to sustain ecosystem integrity and productivity" (USDA Forest Service R-5, 1994).

"Ecosystem management focuses on maintaining ecosystem health which implies that the system maintains its ability to absorb shock and yet retain long-term form and function. It also means that people obtain what they need from ecosystems, while sustaining ecosystem health" (Thomas 1994). Watershed analysis is required to understand key issues and ecological processes.

To simplify and organize management for systems that are overwhelmingly complex, we devise methods to apply ecological theory. As expressed by Egler (1977), "ecosystems are not only more complex than we think, they are more complex than we can think."

To simplify and organize ecosystems, we start by delineating watersheds. The Klamath National Forest delineated 32 analysis watersheds based on true watershed boundaries ranging in size between 28,000 and 123,000 acres. The average size was 66,000 acres.

After delineating watersheds, the next step is to prioritize the order in which watersheds will be analyzed. The Klamath National Forest used several criteria to assist in prioritizing watersheds for analysis. These criteria are:

- Number of species listed, petitioned, proposed, sensitive, or at risk.
- Restoration needs or opportunities.
- Location of landscape within watershed (headwaters are top priority)
- Threats to existing forest health, watershed condition, or meeting desired condition.
- Existing forest health and watershed condition relative to desired condition.
- Habitat features critical to terrestrial and aquatic lifestages.
- Multi-government high interest areas.
- Opportunity to implement activities that foster achievement of desired condition.

After selecting a watershed for analysis, the work begins. We maintain a core team of seven individuals representing skills in wildlife, vegetation, fire, fisheries, hydrology, social science, and writing/editing who are dedicated to watershed analysis. This group functions as a self-directed team. Timeframes for completing the analysis have varied between 3-6 months depending on the size and complexity of the analysis and the level of public involvement.

Watershed analysis is expected to guide Klamath's future monitoring and inventory by disclosing data gaps, describing large-scale relationships, and identifying the information necessary to better understand the ecosystem. There are five steps in the watershed analysis process:

1. **Disturbance Processes and Historic Range of Variability:** Disturbances and past patterns are identified to characterize the historical range of variability for the area.
2. **Landscape Elements:** The existing condition of vegetation and landscape components are described in terms of composition, structure, and function.
3. **Functions, Interactions and Management Opportunities:** Movement of people, organisms, nutrients, energy, their linkages to other landscapes, and interactions with landscape elements are assessed. Sustainable uses are identified that can help retain long-term ecosystem form and function.
4. **Partnerships and Monitoring:** Partnerships with research and the community identify interactions and monitoring needs at larger scales.
5. **Management Direction:** Desired condition is defined by the goals and objectives of management direction. Refinement comes from local knowledge about the unique landscape features, past disturbances, and site capability for the area.

The following examples from the Humbug Landscape Analysis demonstrate how broad patterns of ecosystem interactions relate to man-

agement applications. The Humbug Landscape is within the Klamath Physiographic Province, where forest conditions are drier than they are in the Pacific Northwest. Precipitation ranges between 20-50 inches annually. Elevation ranges from 2,100 to 6,220 feet. The landscape is approximately 28,600 acres (24% is privately owned). It is within a 30 minute drive from Yreka, which has a population of approximately 6,000 people.

Disturbance Processes

Disturbances are an important part of ecosystem stability. In the Humbug Landscape, key natural disturbances include fire and insect epidemics. Prevalent human-caused disturbances include mining, fire exclusion, and timber harvesting.

We used various techniques to assess the historical range of variability. These techniques included interviewing local residents, reading historical documents, gathering historical surveys and inventories, studying fire history and using historical photos to compare the existing composition, structure and arrangement of vegetation.

Examining past land use and settlement patterns helps us understand how humans have influenced ecological systems. Reviewing historical documents led us to some other interesting discoveries. In 1853, 1,000 miners lived along Humbug Creek. Four good sized towns and a township were established and daily stages ran from Yreka to this area. Today, the only remnants of a once booming mining settlement are scattered tin cans, fruit trees, and broken dishes.

Mining tailings, water diversions, and removal of riparian vegetation caused dramatic changes to the stream channel morphology. Species composition shifted in some areas from conifers to dominant willow/maple/alder communities.

Fire has also significantly shaped vegetation across this landscape. Over 60 years of fire history records were analyzed for this landscape, which indicate a fire frequency of 6-12 years. This correlates to research studies of fire scars on trees for the area suggesting that, prior to fire exclusion, frequent fires (characterized by slow-spreading ground fires) were the norm rather than high intensity conflagrations.

Fire suppression has changed the natural fire regime for the Humbug Landscape. The catastrophic Haystack Fire in 1955 significantly shaped vegetative patterns in the Humbug Landscape. This was a high intensity, stand replacing fire which consumed vegetation across 75% of the landscape. Vegetative patterns subsequently resulted in the even-aged distribution of decadent brush. Another result was the post fire establishment of very large plantations (representing over 35% of the landscape). Many of these plantations were pre-commercially thinned. Inadequate fuel treatment adds to fuel accumulations. Today, the landscape is characterized as ecologically unstable because there are contiguous, decadent brushfields and even-aged plantations that are extremely susceptible to another catastrophic fire.

Ecological stress is defined as a force that pushes an ecosystem beyond its threshold or ability to resist or recover. Typically stress results from disturbance that is outside the system's evolved adaptations. Events such as the alteration of disturbance regimes or catastrophic natural events may significantly reduce species diversity or cause shifts in species composition.

In the Humbug Landscape there have been gradual shifts in species composition due to the alteration of the fire regime. The previous Douglas-fir and Sugar Pine dominated overstory has shifted more to ponderosa pine with white fir understory. White fir, which is not well adapted to dry sites, is dying and contributing to more hazardous fuel conditions. Past harvesting of the highly valued Douglas-fir and sugar pine in the overstory also contributed to a shift in species composition.

Landscape Elements

Managing for ecological sustainability entails maintaining biological diversity and ecological integrity. Habitat is determined to a large extent by the composition, structure and pattern of ecosystems. Composition describes the kinds and amounts of plants, animals and other biological and physiological elements in an ecosystem. Structure is the vertical and horizontal arrangement of these elements within and between vegetative patches. Pattern is the arrangement of vegetation across the landscape or linkage with adjacent landscapes.

Humbug Landscape is quite diverse with a variety of brush, hardwoods and conifer species present. The landscape is best described as heterogeneous, comprising a mix of species composition, size, shape and arrangement of vegetation. Vegetation structure is layered with stocking rates generally exceeding the carrying capacity for the site. Key forage species are presently underutilized because of their poor condition and forage quality. Some of the decadent brushfields are impenetrable even to wildlife movement.

Some rare and unique features are present: lush riparian areas along Humbug Creek, *Calochortus persistens* and *Lewisia cotyledon* var. *howellii* (sensitive plants) and very small, disconnected patches of late successional forests.

Large, contiguous biocks of similar vegetation exert strong control over movement of materials, energy and organisms because of the connectivity of habitat it provides, but large blocks of similar vegetation are lacking in the Humbug Landscape. Existing late successional forests or stands exhibiting old growth characteristics are nominal, representing less than one percent for the entire landscape. Humbug Landscape is best described as a fragmented arrangement of habitat.

Fragmentation does not necessarily mean less diversity. "The variety of species in any region depends on the size, variety and dynamics of patches and corridors" (Odum 1982, Turner 1988, Wilson, 1988). "Landscape heterogeneity decreases with the abundance of rare, interior species, increases the abundance of edge species and animals requiring two or more landscape elements. Biotic diversity enhances total species co-existence" (Forman, Godron 1986).

Symptoms of stressed ecosystems may include declines in productivity and changes in how the ecosystem functions from an alteration in disease incidence. From historical records, we learned that a significant beetle epidemic occurred in the spring of 1912 in this landscape. It is evident that overstocking, compounded by cyclic droughts and fire exclusion have exacerbated this situation over time. In 1994, significant mortality is again prevalent.

Riparian corridors are relatively linear features across the landscape. Numerous intermittent and ephemeral channels occur due to the deeply incised inner gorges. Ephemeral and intermittent channels are recognized in the Humbug Landscape as important connective corridors that sometimes offer the only shade, particularly in the eastern portion, where brush dominated slopes offer little cover. Watershed analysis helps us better understand the importance of these channels to downstream beneficial uses and their use by terrestrial and riparian dependent species.

Functions, Interactions and Management Opportunities

Function is the flow of energy, materials and species among ecosystems and landscapes. "Fundamental processes critical to ecosystem function include cycling of nutrients and flow of energy, disturbance regimes and recovery processes (succession), hydrological cycles, weathering and erosion, decomposition, nutrient cycling, herbivory, the biotic food chain, predation, pollination, seed dispersal, and many more. Evolutionary processes, such as mutation, gene flow, and differentiation of populations must also be maintained if the biota is to adapt to changing conditions" (Noss, 1993).

"Flows are ecological phenomenon, living or non-living, that move through or operate within or through the landscape" (Diaz, Apostol, 1992). It is important to focus on the KEY flows within a landscape in order to avoid "analysis paralysis." Identifying key public issues is helpful in determining what is important. Generally, key flows are those likely to be critical in the future which will be affected by human activities.

In the Humbug Landscape, there were eight key flows identified: fire, humans, water, fish, surface erosion, deer, northern spotted owl, and Pacific Fisher. Once key flows are identified, the following questions must be answered to understand ecosystem function:

- Where do the flows and linkages occur within the landscape?
- What vegetative elements influence flows (composition, condition, arrangement)?
- What is the direction of the flow?
- What time of year is this most likely to be found?

Functional interactions for the eight key flows identified in this landscape and management opportunities designed to reproduce key natural processes and functions are described below:

1. **Fire -** Fire has played, and will continue to play, an important role within the landscape. There are over 2,400 acres identified as high fire risk, which is determined by comparing fire history records and the number of fire starts by location to the fuel type and slope class. Map displays of these areas help managers prioritize management treatments based on knowing areas of high fire risk relative to critical habitat areas or private property. Four bands of high-risk occur in proximity to overstocked, multi-layered canopies and scattered trees over decadent brushfields. Fire spread is influenced by fuel loading, fuel moisture, slope and aspect. Fire risk is generally greater from June through September. Vegetative treatments are urgently needed to reduce the fire hazard and return to a fire adapted ecosystem. Exclusion of fire has created a vegetative condition that is not resilient to fire processes or climatic variations (drought). In general the conifer stands are overstocked. This contributes to the continued mortality that is occurring as a result of site competition. Left untreated they present an increased risk to insect and disease infestations and potential loss to wildfire. Left untreated these stands will not rapidly develop the future structural and functional diversity that is desired for the landscape. Reintroducing prescribed fire achieves multiple resource objectives by reducing fire risk, improving forage quality, protecting soil and water quality and wildlife habitat.

2. **Humans -** Humans readily travel through this landscape because of its proximity to Yreka and to access parcels of private ownership. Recreational uses include off-highway vehicle use, mountain biking, picnicking, fishing, hunting, snowmobiling, sledding, and driving for pleasure. Road access enables people to connect with the Klamath River Highway (an eligible State Scenic Highway), the Klamath River (a designated National Recreation River), National Forest campgrounds, and the Interstate freeway. Recreational opportunities include developing an area for recreational gold panning, maintaining the snowplay area, developing an off-road vehicle plan in partnership with the Bureau of Land Management, and maintaining the mountain bike route through the landscape. Renovation of the Deadwood Baldy Fire Lookout could serve as a ski hut in the winter and a picnic or camping site during the summer. Interpretive opportunities abound with the rich history of the gold mining within the area. Cooperative agreements and partnerships still need to be formed with the Siskiyou County Chamber of Commerce, historical societies and local residents to work together in promoting eco-tourism. Exhibits, interpretive trails and pamphlets are in the planning stages. Commercial and precommercial thinning opportunities are identified which benefit multiple resources. Thinning overstocked stands reduces fuel loading and contributes to wildlife habitat objectives while supplying products such as sawlogs, firewood and biomass which stimulates the local economy and provides employment.

3. **Water -** Humbug Creek is the primary year-round source of surface water within the landscape, although in 1994 the main stem has dried up approximately 3 miles upstream from the mouth of the creek. Numerous intermittent and ephemeral channels occur in this landscape. As is typical for a Mediterranean type climate, most of the precipitation is received between September and May. Water flows from Humbug Creek into the Klamath River. Riparian vegetation is dominated by willow/maple/alder/cottonwood vegetation with scattered conifers in the overstory. Some portions are lacking a conifer overstory altogether. Streambank protection and improvement are identified as restoration opportunities. Monitoring water samples from potentially contaminated mining adits are also identified needs.

4. **Fish -** Humbug Creek is a tributary of the Klamath River which is a significant anadromous fishery in the Pacific Northwest. Humbug Creek is considered primarily a steelhead producing stream, although fall chinook, coho salmon and resident trout are found as well. Spawning habitat in Humbug Creek is very good, although the amount of rearing habitat is limited. Subsurface flow during drought years reduce the amount of both the fall run of chinook and coho salmon. Chinook salmon are generally large system spawners and their occurrence in Humbug Creek coincide with high survival rates and in years with adequate flows. Chinook do not travel very far up the creek, usually remaining near the mouth. Coho and steelhead occupy the same reaches, although coho numbers are nominal. The November coho spawning runs overlap with the chinook and steelhead.

   Summer mortality of young steelhead is high because there is not enough suitable pool habitat for half of the population. Seventy-three percent of existing habitat types are low gradient riffles and runs. About half of the steelhead population are found in the limited pool habitat type. Side channel creation and pool deepening are management applications which could increase suitable rearing habitat and improve summer survival rates and the overall sustainability of the steelhead population. Additional opportunities include improving the vegetative structural diversity, and increasing the conifer component within the riparian areas that are currently dominated by cottonwood and alder. Land acquisition has also been identified in order to deepen and stabilize the channel near the mouth of Humbug Creek.

5. **Surface Erosion -** Surface erosion is a key flow identified in the Humbug Landscape. Over 50% of soils in the area are developed from ultramaphic or granitic parent material. These soils are prone to surface erosion because they are coarsely grained with a lack of fine sediments reducing the cohesiveness of soils. Watershed analysis helps locate upslope conditions which may trigger slope failure. The analysis also helps determine the interactions with hydrologic systems and interactions with other processes such as nutrient cycling, sediment delivery to aquatic systems and its deleterious effects to steelhead spawning habitat. Road stabilization opportunities have also been identified.

6. **Deer -** The landscape provides winter range and fawning habitat for deer, as identified by historical deer herd information provided by the California Department of Fish and Game. This wintering area connects with the Klamath River which is an important travel corridor for many of the area's deer herds. Information sharing between agencies is one way to involve peer review and assure that the most up to date and scientifically credible information is being used. The condition and distribution of key forage species, buckbrush (*Ceanothus cuneatus*), deerbrush (*Ceanothus integerrimus*), and western mountain mahogany (*Cercocarpus betuloides)* influence the movement of these herds. Interviews with local residents indicated that 50 years ago brushfields were sparser and of different age classes. Deer were numerous and one could walk through what is now impenetrable manzanita.

   Projects are being planned to increase the proportion of juvenile and mature age classes within brush species. The desired condition is to return portions of brush dominated areas to a mix of age classes which likely existed when frequent, low intensity fires occurred within the landscape. Multiple resource objectives are to improve forage quality by eliminating dead and dying stems, reduce fuel loading, stimulate the germination of seeds stored in the soil, stimulate sprouting, open up impenetrable areas, and increase the amount of grass and forbs. Priority areas for brush treatment are within and adjacent to the key deer winter range. Understanding vegetative responses to fire and plants' adaptive traits are very relevant to management activities. Research and field experience teach us that deerbrush vigorously crown sprouts after fire, whereas

buckbrush and manzanita are readily germinated by seed after fire. Deerbrush will immediately occupy a site by crown sprouting (an adaptive trait for a shorter lived montane species), whereas greenleaf manzanita (longer lived chapparal species) regenerates from heat scarified seed and may require a decade to regain its dominant position. Selecting appropriate intervals between burning cycles can assist competition favoring desirable forage species.

By understanding morphological adaptations, vegetative reproduction strategies, plants' fire tolerance and fire resistant characteristics, we can better achieve desired results in applying management prescriptions. "The ability of a plant to survive fire depends upon food reserve levels (carbohydrates), mode of regeneration and morphological characteristics inherent in the species" (Volland, Dell 1981). Research can help define the appropriate timing for prescribed fire in order to meet specific resource objectives.

Managing hardwood stands by burning or thinning activities is desirable to increase stem diameter, thereby increasing acorn production. Mast (acorns, leaves, twigs and lichens falling to the ground) produce excellent forage for wildlife.

7. **Northern Spotted Owl -** "Vegetative linkages to adjacent landscapes are very important to wide ranging species such as the northern spotted owl and the Pacific Fisher. Linkages function as connections for suitable habitat, for seasonal migrations, for dispersal, and for long-distance migration of species in response to climate change" (Noss 1993). The northern spotted owl prefers well stocked, multi-layered, multi-species canopy dominated by large overstory trees with cavities, broken tops and other signs of decadence. Although contiguous large blocks of connecting habitat are lacking in the Humbug Landscape, this year young owls were found in the nest which was previously designated a territorial single owl site. The presence of owls in this landscape without adequate amounts of suitable habitat indicates their reliance on suitable habitat in adjacent landscapes. This indicates the need for managers to maintain critical habitat linkages with adjacent landscapes.

8. **Pacific Fisher -** Photographic survey stations have documented the presence of Pacific Fisher along a ridgeline between connecting landscapes. This wide ranging species (6,000-9,800 acres) prefers late successional forests for denning sites. Small inclusions of hardwood stands, natural openings, and riparian areas provide additional habitat for foraging. The Humbug Landscape does not provide enough suitable habitat to support this species; however, the adjacent landscape provides connecting suitable habitat and there are opportunities to develop old growth characteristics.Management prescriptions designed to develop old-growth characteristics for both the northern spotted owl and the Pacific Fisher would produce snags, logs on the forest floor, large trees, and canopy gaps that enable establishment of multiple tree layers and diverse species composition, while preventing large-scale disturbances by fire, wind and insects. Small-scale disturbances by natural processes are encouraged to continue.

   Silvicultural applications to develop old growth characteristics include:

   - Thinning or managing the overstory to produce large trees; releasing advanced regeneration of conifers, hardwoods, or other plants; or reduce risk from fire, insects, diseases and other environmental variables;
   - Underplanting to begin development of multistory stands;
   - Killing trees to make snags;
   - Reforestation;
   - Using prescribed fire.

   Thinning prescriptions should encourage development of diverse stands with large trees and a variety of species in the overstory and understory. Prescriptions should vary among stands.

Thinning older plantations will help to reduce high fuel loads and accelerate growth to produce larger trees. Varied spacing techniques, retention of residual large trees, retaining clumps of diverse species (natural regeneration) will contribute to future late successional forests.

Partnerships and Monitoring

Aldo Leopold wrote, "All ethics so far evolved rest upon a single premise: that the individual is a member of a much larger community of interdependent parts." Partnerships with research and the local community are forming to help study and monitor functional interactions within ecosystems.

Thresholds need to be developed for specific ecological indicators in order to assess the health, functionality and sustainability of natural systems. Much work remains to be accomplished on how ecological indicators are selected and how they are measured and monitored so we can better understand interactions among various ecosystems.

Research has been working with ecosystem analysis projects on the Klamath National Forest to help "develop an understanding of landscape dynamics through wildlife habitat relationships and patterns of use" (Laacke 1994). By linking landscape vegetation data to the Wildlife Habitat Relationship Model, GIS maps can provide spatial displays of predicted patterns of wildlife use. Habitat values for reproduction, cover and forage are assigned to various species which enable us to display areas that are potentially utilized by a variety of species or an individual species. Migratory species, large home range species, small home range species, connectivity and fragmentation can be shown based on these habitat values. We can also highlight vegetative conditions that need to be maintained or developed in certain areas to conserve biodiversity.

Neotropical migrant landbirds utilize riparian corridors along Humbug Creek. In 1994 the Klamath National Forest began monitoring migratory birds in this landscape by establishing a series of point count routes and a MAPS Constant Effort Mist Netting Station. The Humbug Creek was selected as a station specifically to study oak woodland habitat relationships. The U.S. Forest Service's monitoring is a cooperative partnership program with Partners in Flight Neotropical Migrant Bird Conservation Program. Monitoring provides baseline information on neotropical migrant bird population trends, breeding bird habitat relationships, and population demographics. About 103 birds have been banded at this site. There appears to be a higher density of brown-headed cowbirds found here as compared with other mixed conifer sites on the forest. The cowbird is found in more disturbed and fragmented habitats, which correlates to the condition of the Humbug Creek riparian area. Neotropical nest parasitism from the cowbird is a concern.

During drought years, subsurface flows reduce the summer steelhead rearing habitat and population for both the fall run of chinook and coho salmon. The construction of dams along the Klamath River regulated the high water flows which were needed to remove alluvial material in the flood plain at the mouth of Humbug Creek. As a result fish passage along Humbug Creek is impaired. Although there are numerous factors such as oceanic conditions, predator populations, drought, dams and overharvesting that contribute to population declines, both species are being petitioned for listing under the Endangered Species Act.

Interagency and tribal partnerships are forming to coordinate a Klamath River Basin Assessment. The objective is to analyze beneficial uses, physical processes, and biological processes for entire Klamath River Basin. This partnership will help identify key issues, ownership patterns, historical land uses, and help to prioritize watershed restoration across jurisdictional boundaries.

"People are part of ecosystems and human conditions are shaped by, and in turn, shape ecosystems. People value and design a broad spectrum of benefits (including survival) from ecosystems. Ecosystem management must include information about people's traditions and changing perceptions, beliefs, attitudes, behaviors, needs and values" (USDA Forest Service R-3, 1993). Partnerships are being developed between the community and the U.S. Forest Service to help diversify the local economy, provide jobs through restoration opportunities, and encourage tourism.

Management Direction

Science is the foundation for informed decision making and sustaining ecological systems while responding to human needs for resources in our charge. How we make decisions is essential to our success in implementing ecosystem management.

Partnerships and collaborative management are essential for understanding and striking a balance of risks and successes in sustaining ecosytems as a whole. This involves working with people throughout the planning and decision making process to assure there are clear expectations of what is to be decided; forming partnerships among people to achieve mutually beneficial goals; seeking a broad perspective of ideas to achieve mutual learning; and sharing power by giving all partners a voice.

The Klamath Forest Plan provides the framework for decisions about how the landscape will appear in the future, and reflects agreements made between the public and the U.S. Forest Service. The Klamath Land Management Plan, which received over 343 public comment letters, is used to determine overall desired condition for a landscape. In the Humbug Landscape there are six management areas designated by the Forest Plan; sensitive species habitat areas, riparian management zones, retention visual quality areas, partial retention quality areas, designated recreational river (Klamath River), and general forest. Implementing goals and objectives for each management area will influence vegetative composition, structure and function over time.

Usually Forest Plan direction does not specifically address landscape pattern but refers to it indirectly, such as creating a mosaic of young, vigorously growing forests made up of a variety of vegetative species. Using our knowledge about specific ecological processes in a landscape such as Humbug helps us to refine the desired condition. In some cases, unique features or critical processes are not uncovered until the watershed analysis is conducted.

We ask the following questions to help refine the desired condition for a landscape so that management applications are based on our understanding of how ecosystems are functioning:

1. Are there some rare, unusual, critical, or unique landscape elements we want to protect or enhance? In the Humbug Landscape, the following unique elements were identified: sensitive plants, late successional forest, steelhead populations, Pacific Fisher, deer winter range, plantations, snags, mountain bike route, recreation mining, mast production, spotted owl and fisher habitat.

2. Are there patches or areas of large forested areas between which connectivity should be maintained? Riparian areas and late successional forest linkages for the spotted owl and fisher were highlighted.

3. Is there anything missing that should be introduced or restored? Reintroduce fire, improve year round water flow in Humbug Creek, develop late successional forests, enhance the conifer component and large woody material along riparian areas, increase grass/forb areas, improve thermal cover at lower elevations, and develop diversity in vegetative structure and brush age classes.

4. To what extent, and where, do we want to emulate certain elements of natural landscape patterns? Within partial retention and retention visual quality areas we want to emulate naturally occurring landscape patterns. Reintroducing fire and creating a more diverse vegetative structure and age class distribution for brush is desired.

5. Are there areas of the landscape where it is desirable to minimize fragmentation? Connect late successional forest parcels to younger stands to provide better habitat connectivity. Connect stands which are a low fire risk. Minimize fragmentation to riparian areas.

6. Are there areas where gradual changes rather than sharp edges are desirable? Habitat connectors should be similar in seral stage type. Stands adjacent to riparian habitat should have more gradual edges. Partial retention and retention visual quality areas desire gradual changes (feathering edges of management activities).

7. Are there areas where a high degree of edge and contrast is desirable? Adjacent to plantations (not used to connect late succes-

sional forests), along ridgelines, private inholdings, and recreation areas may be desirable areas to highlight edge.

What will the Humbug Landscape look like in the future in order to return to a more stable and sustainable ecosystem? There are two major factors that will influence the appearance of the landscape in the future: 1) fire and 2) management direction and applications.

Fire will continue to influence vegetative patterns across the landscape. Fire records and historical information suggest that fires burned every 6 to 12 years in this landscape. At the lower elevations, frequent fires maintained low levels of both standing and ground fuels, burning mainly along the ground rather than in tree crowns. These ground fires perpetuated open, parklike mixed conifer stands of ponderosa pine, sugar pine and Douglas-fir which are more resistant to insects and disease than white fir.

Without management this fire-prone landscape is at risk to a stand replacing catastrophic wildfire because of the high fire risk decadent brushfields, the evenly spaced overstocked plantations, and the overstocked multi-layered natural stands. In the future, the desired condition is to return to a more stable and resilient fire adapted ecosystem. Vegetation would appear more open at lower elevations. Vegetative structure would be less uniformally layered and brushfields would appear as a mosaic of different age classes.

Management direction implies where, how much, and at what rate goods, resources and services will be maintained and provided. In the future, silvicultural activities can accelerate development of future late successional forests at higher elevations, maintain stocking densities and species composition which are more resistant to insect attacks and less prone to crown fires. Riparian areas would be structurally diverse with more conifers in the overstory and greater amounts of woody material in Humbug Creek.

Overall, plantations and natural stands will provide future late successional forests in those areas where connectivity has been identified as important. Silvicultural activities designed to develop wildlife habitat objectives will also produce sustainable products such as firewood, biomass and sawlogs which meet some people's needs from this ecosystem. Management activities will be designed to be visually pleasing and recreational opportunities will be more apparent.

CONCLUSION

This paper has described a process, a path to learn about the behavior of natural systems. "Ecosystems should be managed to retain their integrity; their biological diversity in terms of elements, processes, and interrelated functions" (Kessler, 1993).

Predictions of behavior are generally incomplete and incorrect. Applying science to policy through adaptive management is the only means to begin to produce reliable knowledge. "Adaptive management is based on the notion of management plans predicated on experiments. These experiments have appropriate monitoring and feedback loops to ensure short-term flexibility and the long-term learning needed to correct the course" (Thomas 1994). "Adaptive management is highly advantageous when policymakers face uncertainty,....But the adaptive approach is not free: the costs of information gathering and the political risks of having clearly identified failures are two of the barriers to its use" (Lee 1993).

Some natural processes have been significantly altered by a number of impacts including development, agriculture, introduction of non-native species and alteration of natural fire regimes. Replicating large-scale disturbances such as major flooding, channel scouring, and large scale vegetative successional changes are not necessarily desirable. "We cannot...expect that, in the absence of human intervention, those dynamic processes and components will go on functioning as if technological humankind had not altered them. We have created a world that we are obliged to manage" (Christiansen 1990).

There appears to be little argument that a long-term strategy for conserving biodiversity must:

1. Be coordinated across ownerships (California State Resources Agency 1991)
2. Address multiple scales (Noss 1990)
3. Embrace adaptive management (Holling 1978, Walters 1986)

4. Strongly consider the needs of people (Everett et al. 1993)

5. Include a substantial monitoring program and coordination with research.

Environmental questions are complex and often lack definite answers. When we consider sustaining ecosystems, we need to project activities and effects over long timeframes that are spatially linked.

The answer, we believe, is to move forward using our best stewardship approach to sustainability. Management that is designed to reproduce key natural influences upon ecosytems and maintain processes within them is our best approach to sustain ecosystem integrity and productivity. We expect to learn as we go.

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CASE STUDIES

The sustainable management of forestry resources in Quintana Roo, Mexico

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Abstract.—The first attempts to make a proper use of the forest resources in the Quintana Roo state started at the beginning of this century, when the production of palo de tinte, mahogany, and chewing gum was important. In 1983 the federal and state governments fixed a new forestry policy with the principal focus of creating the conditions for conserving and managing forest vegetation. The initial strategy of this plan considered these action steps:

- Technical assistance
- Forest management
- Training
- Organization
- Forestry industry and commercialization.

This paper presents four stages of implementation between 1983 and 1994 to obtain sustainable management of the forest resources in the state of Quintana Roo.

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An overview of the Chattooga Ecosystem Management Demonstration Project

David C. Cawrse[1]

ABSTRACT.—The Chattooga Ecosystem Management Demonstration Project had its start in 1991 from a request developed by a coalition of five environmental groups concerned about the biodiversity in the Chattooga River watershed. The Forest Service Southern Region has also recognized this as a unique ecosystem, and has implemented a three year ecosystem management project. Management of this watershed is very complex as it is administered by three ranger districts, each on a different National Forest in a different state. The ultimate goal of this project is to develop an integrated and ecological approach to managing the Chattooga watershed. This includes developing the latest tools and information that will assist in making better decisions. Some of the tools include Geographic Information Systems and ecosystem classification; some of the information includes information on water quality and biodiversity, and public expectations for the area. These tools and information will assist managers in making better decisions while adaptively managing the National Forests. Several projects are underway which incorporate this ecological approach. This approach is aimed at meeting society's demands for forests that are as diverse, healthy, and beautiful as they are useful.

BACKGROUND

The Chattooga River watershed is located where the states of North Carolina, South Carolina, and Georgia meet. It contains 180,000 acres, two thirds of which is National Forest System lands. The 57 mile Chattooga River, considered to be the flagship of the Wild and Scenic Rivers, forms the boundary between the South Carolina and North Carolina. The tremendous diversity of plants and wildlife is due to over 80 inches of annual precipitation and a range of elevations from 1200 ft. to 4800 ft. Federal land acquisition was initiated in 1916. These lands were typical of the "lands nobody wanted" - much of it logged over, with some areas intensively farmed and grazed. The present vegetation is a mix of pine and hardwoods. The area is used for hunting, fishing, sightseeing, rafting, and logging. Recreational use of the watershed increased after the movie "Deliverance" was filmed there. This has created tension between local residents, new residents who moved to the area for its environmental qualities, and recreationists who use the river.

Management of this watershed is very complex as it is administered by three ranger districts, each on a different national forest in a different state. The three Forest Plans, developed independently, only partially match in management area boundaries or direction. Water quality and uses of the Chattooga River are a concern. Allocating uses and maintaining the diversity within the watershed are other challenges. Expectations range from primitive recreation and preservation, to commodity

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production. Appeals, litigation, and user conflicts have increased throughout much of the watershed, and are leading to alternative harvest methods and increased public involvement.

The Chattooga Ecosystem Management Demonstration Project had its start in 1991 from a request developed by a coalition of five environmental groups concerned about the biodiversity in the Chattooga River watershed. The Forest Service Southern Region has also recognized this as a unique ecosystem. The Region has implemented this three year project to address the challenges mentioned above.

CHALLENGE

The primary goal of this project is to develop an integrated and ecological approach to managing the Chattooga watershed. This approach is aimed at meeting society's demands for forests that are as diverse, healthy, and beautiful as they are useful. Four principles of ecosystem management - integration, sustainability, public participation, and collaboration - are addressed by several working groups, as well as by on-going projects on individual districts. One emphasis of this project will be the conservation of biodiversity within the watershed through sustainable resource management. Researchers will be consulted, and the public will be invited to participate in identifying long term management goals for the Chattooga watershed.

ECOLOGICAL APPROACH

This project will provide information and state-of-the-art analysis tools to aid resource managers in their work. The information and tools from each of these working groups should help managers make informed decisions that are sensitive to the unique values in this area. Decisions will still be made at the Forest level and at the District project level. Individual Forests will be responsible to use and integrate this information at both levels, with coordination provided by the Chattooga project coordinator. The working groups for the Chattooga project are the following:

GIS (Geographic Information System)—Accelerate GIS technology and coordinate the development of an integrated data base for the basin. This will include developing a database that crosses political boundaries of states and focuses on the Chattooga River as a watershed. Graphic information related to the vegetative composition and structure will be developed in addition to such standard things as information on roads, streams, and landownership.

Ecological Land Classification—Complete ecological land classification for the basin. It will be compatible with the Forest Service National and Regional ecosystem classification hierarchy. This system will be well defined and described at all levels of the hierarchy, and capable of being implemented on the ground by district Forest Service personnel. Ecological units will be an integration of soils, plants, and geomorphology, and will include classification for both private and public lands. Defining ecological units will help managers assess responses and impacts on these units, and assist with knowledge on distribution of species and disturbance patterns.

Biodiversity—Develop and test a process which will enable the National Forests to inventory and assess biodiversity for forest and project planning in the Southern Blue Ridge area. This process will provide the tools and methodology for analyzing and comparing historical, current, and potential ecological conditions and disturbances. The process will address composition, structure, and function at several scales. Likely outcomes may include the identification of elements or components (species, communities) at risk at the local level, with applications at the regional level. This process will use a coarse filter approach (looking at landscape level processes and disturbances to define the natural range of variation) and a fine filter approach (identifying and inventorying rare communities and species).

Public Participation—Through public involvement, define a desired future condition of the National Forest lands of the Chattooga basin. For the desired condition of the watershed, a shared vision or an endorsement of a desired condition could be reached that would be used in the revision of each Forest Plan. Principled negotiation

will be used to develop the desired conditions for the drainage, where values and principles are described for the watershed rather than people's positions.

Water Quality—Provide an indepth evaluation of the existing condition of the water quality of the Chattooga basin. Data will gathered on physical (temperature and sedimentation), biological (fish and insects), and chemical (fecal coliform) conditions. The existing condition will be compared with the desired condition. Opportunities and practices will be identified that would be needed to meet desired conditions. Funding opportunities through partnerships will be explored in order to implement these practices.

Lands—Establish land acquisition and exchange needs and priorities for the watershed, which includes providing information to achieve the optimal National Forest System land pattern.

ADAPTIVE MANAGEMENT

One of the most important parts of the project is implementation of what we have learned. This can be considered adaptive management. The following is a sampling of projects in which ecosystem management is being implemented in the drainage basin.

Water Quality—On-going studies of riparian ecosystems and management strategies are being coordinated through the Chattooga Coalition (for fisheries), which is a coalition of state Department of Natural Resources, National Forests and Trout Unlimited Councils. In another effort, an EPA grant was recently awarded to the town of Clayton for improvement of Stekoa Creek, an impaired tributary of the Chattooga River. The Stekoa Creek action group, which includes concerned citizens, user groups, and agencies (including the Forest Service), helped develop this grant. The grant will help apply Best Management Practices on a voluntary basis for areas with non-point source pollution problems.

Hanging Rock Project—A coordinated effort between the Highlands and Tallulah District to incorporate an ecological approach to vegetation management. One of the tools used was a large scale prescribed burn coordinated between the two different states. The 300+ acre burn was completed last spring, with additional burning planned next spring. The project also involves uneven-aged management of white pine.

Big Creek/Clear Creek Project—This project, started in 1990, involved describing desired conditions for old growth and other resources, and developing practices to meet those conditions. Management of white pine in small groups was implemented (about 1/4 acre in size). Other resources were addressed and partnerships created, such as North Carolina Dept. of Transportation fixing long term sedimentation problems on Walking Stick road.

Tuckaluge Project—A proposed project which involves changing the species composition from white pine to hardwoods through prescribed burning and timber harvesting. This will be integrated with other recreation and wildlife enhancement projects. The project also includes the regeneration of table mountain pine (a unique fire dependent species), and wildlife enhancement projects. A landscape analysis and design, which utilizes GIS and ecological classification, is being used. The outline for this process is borrowed from Region 6 (Pacific Northwest).

Pine Management—The uneven-age management of both white and yellow pine is being prescribed with the assistance of research silviculturists Don Beck and Jim Baker. In areas where a recent tornado hit, the plant association map was used to determine the natural species composition for those areas. Either planting of shortleaf pine or natural regeneration will be used to maintain the natural forest diversity.

Other Management Changes—Districts have begun to use single-tree selection on many projects (clearcutting will only be used where it is determined to be essential). Larger scale projects are being implemented in cooperation with adjacent Forests and Districts. On the Tallulah Ranger District, some of the past sales under contract have been modified, with the net result the elimination of clearcutting and also dropping 21% of the total acres of harvest in the Chattooga River watershed. Also, single-tree selection has included treatments

for retaining all the white oak component regardless of management type of the stand (white oak is a long lived species). All districts are shifting to use of a plant association map that describes potential natural vegetation. For the upper two thirds of the watershed, this means a shift from a species composition of primarily pine to one of primarily hardwoods, which will be managed on longer rotations. Also the amount of volume that is planned to be harvested from the Chattooga watershed has decreased significantly from levels in the 1980s due to reductions in harvest levels for all 3 forest plans.

PARTNERSHIPS

Several universities are partnering with the Chattooga project. These include: Clemson University - Chattooga River visitor study, completion of the sediment study, the Chattooga Coalition fisheries work, and neotropical migratory bird research; Duke University - Public involvement work; and NC State University - Assistance in use of Geographic Information systems to develop plant associations for classification, neotropical migratory bird research, salamander research, and permanent growth plots to measure vegetative changes. The USDA Forest Service Southeast Research Station is involved in studies of water quality, white pine regeneration, habitat and population of fisheries, and ecosystem classification. Southern Appalachian Man and the Biosphere program has assisted in the public involvement aspects of the project. The three outfitter and guides on the river are Challenge Cost Share partners. For every customer, 25 cents is put into a fund for water quality projects and education within the watershed.

CONCLUSION

The biggest challenge this project offers is implementing integrated resource management at a large scale, with the retention of biodiversity as an overriding objective. Most of the individual projects–ecosystem classification, GIS, water quality monitoring, public involvement, and land adjustment–are not totally new. What is new is the scale at which they are applied–across three states in three National Forests in a unique watershed.

Research to support ecosystem management in the Chattooga River Demonstration Project

Charles C. Van Sickle[1]

Abstract.—The relationship between research and management is often indirect and not visible. Nevertheless, it is useful to note parallels between our research approach and ecosystem management in general. Ecosystem management requires attention to several different landscape scales. It is logical for research supporting this concept to also address several different scales. Variation in spatial scale ranges from site specific to regional, and time scale ranges from immediate to a continuous program of monitoring and evaluation. Ecological classification is essential to provide a framework for management and to allow extrapolation of research findings. Synthesis and integration may be accomplished in several ways but a computer-based decision support system is a useful mechanism. An understanding of human needs and values is critical and may require a different approach at different scales. This paper describes research at regional, watershed, and project scales.

The Chattooga River Demonstration Project, described in the previous presentation, illustrates several technical and administrative challenges that ecosystem management has brought to the forefront. The part that research has played, and the relationship between research and management, is often indirect and not very visible. Nevertheless, there is both an immediate and long-term role for research.

To understand the role of research, it is useful to note the parallel between our research approach and ecosystem management in general. That is, that both research and management must address a variety of scales. Especially important is the need to take a broad scale overview of the ecosystem and to understand how the components function together. Thus, the research needed to support the Chattooga River Demonstration is part of a larger program currently underway in the Southern Appalachian region. Further, that the Forest Service Research program is part of a more comprehensive interagency assessment.

When we first contemplated our ecosystem management research program for the Southern Appalachians, we had to decide whether to concentrate our research in a single watershed (hoping that we could extrapolate our findings to other areas) or to disperse our research efforts across the region, and attempt to synthesize the results in an ecosystem model. We chose the latter approach because it would allow us to work with several national forests simultaneously. As a result, we now have studies underway at numerous locations within the Southern Appalachian region which can directly support ecosystem management on the Chattooga and elsewhere. I'm going to briefly describe this program and highlight future actions that can be taken to establish a working relationship between research and management.

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SOUTHERN APPALACHIAN ASSESSMENT

The eight national forests in the Southern Appalachians are an important feature of the region and comprise about one-fifth of the total area. The main purpose of the Southern Appalachian Assessment is to show how national forests are affected by the conditions that occur on surrounding private lands and the Great Smoky Mountain National Park. And conversely, how management decisions on national forests affect private lands. Understanding the context for managing the national forests will be accomplished through the close cooperation of research and management. Analyzing the relationships between the region's national forests and the lands surrounding them will also involve other Federal and State agencies with similar interests and responsibilities. In fact, other agencies, especially the Environmental Protection Agency (EPA), already have work underway on the assessment initiative.

The Assessment is a partnership with other Federal agencies. The differing responsibilities and capabilities of various Federal and State agencies make cooperation one of the attractive aspects of ecosystem management. Government agencies can bring specialized expertise, data, and organizational resources to bear on environmental problems. More importantly, the process of collective thinking and planning adds new insight and depth to problemsolving. Several of the agencies involved in the Southern Appalachian Assessment have research components. These groups have been loosely organized into a network that can coordinate research and share information. The primary mechanism for interagency coordination is the Southern Appalachian Man and Biosphere program (SAMAB). SAMAB was organized several years ago to facilitate a dialogue between the agencies on matters affecting the network of biosphere reserves. It has since become a major factor in interagency coordination.

The public must be involved in matters that affect land management and Government policy. Sometimes we are inclined to think that there are fundamental values that natural processes possess. But as Hugo Manzania has stated so eloquently, all values are ultimately derived from human perceptions and needs. A critical part of ecosystem management and research is sensing and analyzing the way that people and their culture relate to natural resources. Cultural changes brought about by population growth, shifts in land use patterns, changes in educational and cultural development, and many other factors are altering peoples attitudes about natural resources. These changes can be better understood by inviting people to express their feelings and ideas about natural resource management. The cultural change within the region is also impacting the environment. Air quality, water quality, land use patterns, habitat quality, and forest use are all influenced by human population and social changes.

The Assessment identifies relationships between landscape features, resources, ecological processes, and people. The broad scale of a regional assessment makes it best suited to examine relationships between geographic, social, and biological factors. The broad spatial scale should also be matched by a similarly broad time scale. That is, the emphasis should be on understanding current conditions and the sweeping changes that brought them about.

There are many illustrations of the scale required for assessment level analysis, but a useful one is associated with forest health. Gypsy moth outbreaks have been moving steadily south through the Appalachians for almost two decades. This defoliating insect prefers oaks, although severe outbreaks affect almost all trees. The effect on the landscape has been to alter species composition, stand structure, and to directly affect water quality and aquatic habitat. The insect has been a special nuisance when it affects trees in cities and suburban areas. The Southern Appalachian Assessment will evaluate the potential influence of this pest on future forest conditions and outline possible control strategies. It will also help establish research priorities and justify investment of public tax dollars.

The role of research is to help synthesize information to better understand relationships. The rapid recognition and shift in emphasis to ecosystem management has often seemed to place researchers in the role of providing technical assistance rather than developing new knowledge. Even when we recognize that ecosystem management requires a broad continuum from short-term research to long-term programs, most researchers have found themselves regarded as a consultant

rather than a scientist. Thus, it is easy to overlook the knowledge and value that can be gained from the synthesis of existing information into new and emerging relationships. Synthesis is one of the vital roles of interdisciplinary (ID) teams—the integration of several different scientific and resource perspectives. Synthesis also occurs when the cumulative effects of management actions are evaluated at larger scales. The complex and often baffling issue of managing for biological diversity or sustainability are issues that will challenge researchers without requiring new data. In short, there is an important opportunity for research in developing greater insight from the information we have available.

Monitoring is essential for management and research. Monitoring is a function and activity that in practice is poorly defined and often misunderstood. In this context, I am using the term to mean a process of systematically keeping track of the way ecosystems respond to both management and external change. Monitoring is critical to determine the rate of progress toward the desired management objectives and to give early warning of environmental problems. Monitoring can also provide valuable scientific information about the way ecosystems function and behave. Not enough attention has been given to coordinating the design of monitoring so that management and research objectives can both be met.

Monitoring characteristics are likely to differ by scale. Initial data for the regional assessment will be supplied by the Forest Inventory and Analysis (Survey), by Forest Health Monitoring programs conducted by Forest Service and EPA, and by such programs as the National Water Quality Assessment of the U.S. Geological Survey. The Assessment will also assemble several regional data layers to serve as the basis for the Geographic Information System. These elements are a good starting point but part of the Assessment should provide guidelines for future monitoring.

SOUTHERN APPALACHIAN RESEARCH PROGRAM

The brief overview of the Assessment describes one level of research and management interaction. Closely related to it, but initiated 2 years earlier, is the Southern Appalachian Research program. This program was designed to address more local ecosystem management concerns and was specifically targeted to management on the national forests. It now serves as a link between the Assessment and projects such as the Chattooga River Demonstration.

Our overall approach was to redirect ongoing research efforts and to initiate new research to provide needed information for ecosystem management. Wherever feasible, interdisciplinary approaches have been used. However, integration of information across disciplines and spatial scales will also be facilitated by development of a decision support system described below. Research activities are organized into three broad categories:

- Ecosystem dynamics, structure, and function.
- Social and economic influences in ecosystem management.
- Synthesis and integration of information.

Studies are being conducted at spatial scales appropriate to the objective of study—some studies focus on stand-level responses while others examine responses at larger spatial scales. And, collectively, they are representative of the varied conditions that exist across the region. Individual studies are supported by study plans or cooperative research proposals. Some of the components are as follows:

ECOSYSTEM DYNAMICS, STRUCTURE, AND FUNCTION

- Developing the ecological information necessary to support an Ecological Classification System.
- Ecological effects of soil nutrient gradient and other soil factors on vegetation distribution and productivity.
- The nature and measurement of biological diversity.
- Neotropical migratory birds: population changes, productivity, and effects of silvicultural practices.
- Cumulative effects of land use practices on water quality.

- Effects of manipulating riparian and an in-stream habitat on endemic fish communities.
- Attributes of old-growth communities.
- Effects of regeneration methods on vascular plant diversity.
- Effects of regeneration methods on salamander populations.
- Effects of prescribed fire/white pine establishment on plant diversity.
- Regeneration in white pine/hardwoods using group selection.
- Regeneration response on intermediate and xeric sites.
- Prescribed fire severity and soil movement.

SOCIAL AND ECONOMIC INFLUENCES IN ECOSYSTEM MANAGEMENT

- Valuation of noncommodity forest resources.
- Effects of regeneration methods on visual quality.
- Evaluating and predicting changes in land-use.
- Effects of forest recreation on rural communities.
- Use of conflict resolution techniques in forest planning.
- Identification of management and research needs in the social sciences.

SYNTHESIS AND INTEGRATION OF INFORMATION

The Southern Appalachian Research Program is one of our first attempts to create a broad ID team. We began by establishing an ID team to both design and conduct the research program. It didn't quite work according to plan and we have much to learn about making research teams work together. The result was a set of related but independent studies scattered through the region. Although the program was somewhat fragmented, it was well coordinated and combined most of the relevant parts of our Station's faculty. The program is also supplemented through research with cooperating universities and Federal agencies. Part of the effort to coordinate the Station's research is through organizing focused workshops. Two are currently planned—a national workshop on the social dimensions of ecosystem management and a regional workshop to feature current experience in mountain forestry.

In the region-wide research program, the integrating mechanism is a computer-based decision support system. This system is an adaptation of a decision model developed by the Northeastern Research Station. All four of the eastern research stations are now involved in some way with the development of this model.

A decision support system provides a framework for storing ecological response data obtained from many sources. It is supplied in a form that allows managers to readily obtain information about the consequences of alternative management actions. We consider it a key link between research and management.

WATERSHED STUDIES - WINE SPRING CREEK

One component of the Southern Appalachian Research program (but at the next lower scale) is the Wine Spring Creek project. This small watershed is similar in size to compartments frequently used as management units. The approach is to employ an ID team to examine ecological responses on a single 2000 hectare watershed on the Nantahala National Forest as a part of a land management plan. The project established desired future conditions for the area based on the general specifications established in the forest plan. The project will develop and test alternative means for moving from existing conditions toward desired conditions. The research will predict and evaluate ecosystem responses. Desired future conditions may be amended or expanded as information from interdisciplinary resource surveys and research becomes available. For example, location and management of old-growth areas may change over time as old-growth attributes become better defined and inventoried. Individual or integrated projects for achieving desired conditions will be developed and analyzed.

Watersheds, such as Wine Spring Creek, serve as an integrating mechanism at a more local scale. Indeed, most management actions can be directly measured by their effect on water chemistry and sediment load. In contrast to the broad scale research efforts, extrapolation of results will be highly dependent on accurate ecological classification—classification of the Wine Spring Creek watershed correlated with similar watersheds. The limited size of the Wine Spring Creek unit is condusive to close cooperation with the local management organization. The Wayah Ranger District is a major partner in the conduct of this research program. One disadvantage is that other Forest Service managers seem to have little interest in research projects that don't take place directly within their administrative boundaries. Communication of research findings throughout a highly dispersed organization is a difficult challenge.

SUMMARY

Now I would like to offer a few conclusions. Ecosystem management is a concept that requires attention to several different landscape scales. It is logical, therefore, for the research to support this concept to also address several different scales. The variation in spatial scale ranges from site specific to regional and the time scale ranges from immediate to a continuous program of monitoring and evaluation. Ecological classification is essential to provide a framework for management and to allow extrapolation of research findings. Synthesis and integration may be accomplished in several ways but a computer-based decision support system is a very useful mechanism. An understanding of human needs and values is critical and may require a different approach at different scales. Above all, ecosystem management is a partnership between manager and researcher.

Ecosystem management applied to a piñon-juniper/ sagebrush vegetative area in northern New Mexico

Daniel L. Rael[1], Mark T. Lujan[2], Palemon A. Martinez[3], and Brett T. Coleman[1]

Abstract.—Ecosystem management concepts were used to describe the desired future condition of National Forest System lands within the Tres Piedras Ranger District on the Carson National Forest. Unsatisfactory watershed condition, piñon-juniper/sagebrush vegetation cover types, and watershed boundaries defined the Lower Petaca Management Area. Using ecologic, economic, and social considerations, a desired condition statement for the Area was produced. Public participation was actively solicited and encouraged. Partnerships with resource users and researchers were developed.

LOWER PETACA ECOSYSTEM PROJECT

By Daniel Rael

One of my heroes is Aldo Leopold, father of wildlife management and early conservationist who worked in Tres Piedras, New Mexico in 1911. He said: "After many days of much riding down among thickets of detail and box canyons of routine, it sometimes profits a man to top out on a high ridge, leave without pay, and take a look around" (Leopold 1913). Damas y caballeros, I climbed onto a high peak and took a look around the Petaca watershed. This afternoon I will discuss what I saw and what we have learned in the Lower Petaca Ecosystem Project.

To discuss the Lower Petaca Ecosystem Project, I have brought distinguished guests who will assist me in a team approach to this presentation. They are: Mark T. Lujan, Native American Scholar, Taos Pueblo; Palemon Martinez, Cerro Azul Grazing Association Officer, and Brett Coleman, Range Conservationist, Project Leader.

We come from the Southwest region of the U.S. Forest Service and our mission is: "Caring for the Land and Serving People". This project demonstrates an ecological approach to multiple use management, with strong consideration to the human dimension of ecosystem management. The project recognizes the unique multicultural atmosphere of the area with Native Americans, Hispanos, and Anglos. It is sensitive to human values including cultural, spiritual, emotional, historical, economic, legal, and political values.

This project is modeled after the Piñon-Juniper Initiative which is successful due to the efforts of Mr. Jose Salinas of the Southwest Region. It also includes considerations of the Forest Health Initiative which calls for increased prescribed burning in the National Forests.

The Lower Petaca Ecosystem Project is based on several factors. The project area is over 100,000 acres of National Forest and another 100,000 acres of Bureau of Land Management, New Mexico State Lands, and private lands. The project is named for the Arroyo Aguaje de la Petaca which is a subwatershed to the Rio Grande. We are managing

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over a longer timeframe of 250 years and based the project on ecological principles including, Productivity, Sustainability, and Diversity.

The project is the result of many field trips on the ground, presentations, discussions, debate, and collaboration. As a result we have generated understanding, trust, credibility, and support from a diverse group of people.

Why was this area selected as an Ecosystem Demonstration project?

First of all, surveys indicated portions of the watershed are in poor condition. Deep gullies are forming, topsoil is being lost, revegetation areas are declining in productivity and diversity, sagebrush and piñon-juniper stands are increasing, and crowding out desirable native forbs, shrubs and grasses, grazing and firewood gathering need to be analyzed for sustainability, and numerous roads are causing erosion. These are serious problems, and it is my job, my duty, my responsibility to manage these valuable natural resources. I take this very seriously and will work hard to the best of my ability.

What is an ecosystem and how do you manage a landscape of over 100,000 acres? First are physical factors to consider; including geology, soil, climate, topography, and precipitation. The project area is in a high valley with a semi-desert climate and gently rolling topography. The major limiting factors are precipitation and available plant moisture.

The physical resources support a vegetation community of trees, grasses, shrubs, forbs, and cryptogams. Vegetation composition ranges from 300 year old Piñon-Juniper stands to sagebrush-grasslands. Early accounts by explorers, soldiers, and scientists over the past 300 years describe Piñon-Juniper stands with a savannah look, characterized by large diameter, full crowned, widely spaced trees that supported more native grasses, shrubs, and forbs than is found today. The sagebrush-grassland stands had a much lower density of sagebrush than is found today. Historic overgrazing in the late 1800's and the suppression of wildfires for the past 100 years have caused large increases in sagebrush and piñon-juniper and less densities of grasses, shrubs, and forbs. Every plant is a miracle, it takes the right combination of sunlight, nutrients, and moisture, and then must compete with all other plants in the immediate area to survive.

The physical resources such as soil and climate that produces vegetation, in turn supports a wide diversity of animals. Native wildlife species include large mammals such as mule deer, elk, black bear; small mammals such as fox and coyote; raptors such as red-tailed hawks, golden eagles, turkey vultures; small birds such as piñon jays and bluebirds, reptiles such as rattlesnakes, and rodents like deer mice, prairie dogs, and ground squirrels.

The Lower Petaca Ecosystem Area is managed on ecological principles of Sustainability, goods and services over long periods of time; Productivity, the land producing to its potential, and Diversity, since wide varieties of plants and animals bring stability to an ecosystem.

Compañeros, it is our duty as resource managers to manage these lands to be as productive as possible, for today and future generations, with a wide diversity of plant and animal species. All ages and sizes represented, and their arrangement on the landscape is very important. How dull life would be if all plants, animals, and humans were all the same!

Most important of all, and the reason why this project was selected as a case study for this symposium, is ecosystem management must consider human values and their relationship to the land. In this project, we have gone to great lengths to talk and listen to people about their land ethic, their dependence, and traditional uses. Describing and defining cultural, spiritual, and aesthetic values can help us as resource managers, to do a better job. Even though I am a resource manager, I spend more time managing people with different values that have tremendous influence on the legal and political aspects of my job.

The Lower Petaca Ecosystem Project recognizes the multicultural aspects and environmental ethics of: Native Americans, Hispanos, and Anglos. It does not matter where you live, people have a relationship to the land, a land ethic .In the Petaca area, the Taos Pueblo is our neighbor to the east. Their ancestors lived in the valley for thousands of years and even today are dependent on the area for religious, traditional, and medicinal uses. Mark Lujan will discuss this aspect further.

The Spanish conquistadores came to this area in the mid-1500's looking for gold, glory, and God. The colonists that came north and stayed, settled

in the valleys close to water where they grew their food in private, irrigated lands. Isolated for hundreds of years, they were totally dependent on the land for firewood, building material, (sand, stone, lumber) and forage for their sheep, goats, and cattle. To the Hispano today, the Floresta lands represent the communal lands of the land grants. Their heritage brings them to the mountains as often as they can. Their land ethic is that the land is here to serve the needs of people, not just to look at. Palemon Martinez will elaborate on this.

In the late 1800's, the Anglo settlers that lived in and around the project area brought more mining, logging, and ranching. Their descendents prefer the rural way of life, which is isolated and insulated from many big city problems. Randy Schofield, a rancher from Tres Piedras said it best: "People of the area do care for the land. They do not care about being rich with money. They want an enjoyable way of life. They realize the hardships their ancestors endured to settle this land, including loss of loved ones. They had to deal with drought, disease, wolves, bears, and lions. People just want to sustain and enjoy a rural way of life established by their ancestors."

Today, in 1994, new residents are attracted to the area. Six major subdivisions are planned around the project area. They are attracted by the natural beauty, undeveloped, inexpensive land, and low populations. They also bring in new ideas that often conflict with local values.

The next presentation is by Mr. Mark Lujan who is a McNair scholar student currently working on a B.S. in Wildlife Biology at New Mexico State University in Las Cruces, New Mexico. Mark has served as head ranger for the Taos Pueblo Blue Lake Wilderness Protection program from 1988-92. Mark will discuss the "Native American Perspective on Ecosystem Management, Sustainability, and Partnerships.

TAOS PUEBLO CULTURAL PERSPECTIVE

By Mark Lujan

I, Mark Lujan, am from Taos Pueblo in northern New Mexico, USA. From time immemorial, my people have lived in the Taos valley. The Lower Petaca Management Area is part of my people's aboriginal land claim. I wish to put in perspective three aspects of this area as it relates to my tribe, which are ecosystem management, sustainability, and partnership.

As you may gather or interpret, my people had ecosystem management in mind prior to 1992, when the Forest Service announced its new direction. It is safe to say that my people have always had an association with Mother Earth. Also, we give thanks for the air we breathe and the water we drink. Now, some people may still view this as weird worship. The Taos Indians, as well as those tribes who share in La Petaca area, take the concept of ecosystem management a step further by embodying it in their respective ways of life.

So far, the definitions of sustainable ecosystem management are many. From the Pueblo Indian perspective, this means clean air, clean water, and resources for present and future generations. Upon contemplation, we must consider past, present, and future conditions and implications of our actions. We, of Taos Pueblo, for our view of sustainable ecosystem managers, have been scrutinized, criticized, ridiculed for so long, even though our belief in managing our ecosystems continues.

We realize that we are not alone in our efforts at sustainable ecosystem management. We recognize a conscientious effort on the part of those who are committed and dedicated to this process. Our environmental ethic transcends to those who have followed us into the broader Taos Valley and the inclusive La Petaca management area.

What we, as a human race are aware of, is that we must work together, whether it concerns our environment or our personal contacts. With the exponential increase in world population, as managers and individuals, we can view models such as the La Petaca management area for examples and solutions. As we encroach upon the last available space, we must be diligent in our efforts toward sustainable ecosystem management for our generation and those yet to be born.

I leave you with this saying from Chief Seattle of the Duwamish Tribe:

> "What would happen to man if the beast were gone; he would die of great loneliness. For what happens to the beast also happens to humankind."

HISPANIC CULTURAL PERSPECTIVE

By Palemon Martinez

The situation in our area has changed dramatically over the past 200 years. I, Palemon Martinez, want to convey some observations of this area with a view of cultural and historical information that is relevant to current considerations for ecosystem management on the Petaca Watershed. I would also like to share a view of an approach that works and that I feel is essential as we work on an ecosystem approach on this management process. This approach is the principle of partnerships, between land managers and major resource users.

I can trace my family roots to settlement in the Taos Valley, New Mexico, since 1804, with a direct and active role in natural resource utilization and management during this time span and which continues through the present. A historical document shows that Cristobal Matin, my great-great-great grandfather settled in my home community in 1804 and was a farmer in Arroyo Seco. My paternal grandfather, according to my father, was orphaned at the age of twelve in 1860. He started work as a sheepherder and was compensated with sheep. During my younger days, I witnessed his active and major involvement as one of the major farming and ranching families in this area. An area known as the grain center of the west and as a livestock producing area. Juan De Dios Martinez, my grandfather, and his extended family were the principal resource users in the Petaca Watershed. Some descendants, including myself, are still users. More on my experience later.

At this time, I would like to share with you some sense of history and land use in this area.

An agricultural census of Taos County communities dated 1860 and recently found by an anthropologist, shows the makeup of a community listed by name. It lists residents by name, agricultural economic data, number of horses, cattle, sheep, burros, etc. I am intrigued by the individual information listed and it gives me a feel of what may have been occurring in the area. I can associate families with some of the names listed.

Noting the census record with sheep as a major enterprise, this historical photo shows a loaded caravan ready to move with their shipment of wool. I recall a very similar family wool shipment caravan in the late 1930's, shipping wool to a railroad pickup point in Jaroso, Colorado. This time, however, it was a truck caravan. The shipping point was bustling with activity with wool growers from New Mexico and Colorado. As a child, this was an exciting experience for me and my younger brother. A noted historian, John Baxter, has authored a book entitled "Las Carneradas", dealing with the extensive sheep industry in New Mexico with shipments to the western United States and Mexico. Sheep were a dominant resource user in the Petaca Watershed. I should point out that sheep and cattle production has always been important to the native Hispanic communities in northern New Mexico and southern Colorado. Families and their survival were of utmost importance during this period and is still a major factor and consideration even today. A photo taken at the turn of the century, shows a wood hauling caravan headed towards Taos from the area west of the Rio Grande, then known as the Rio Norte, and coming from the Petaca Watershed area. It sits behind the historic Taos Pueblo.

Wood was the sole source of fuel for cooking and heating. For many residents of our area, it is still the sole source of fuel and to most, a heating supplement. This wood product and lumber have always been an important and valuable natural resource to our area residents and important in our Petaca ecosystem. I can't help but reminisce to my elementary and secondary school days when my weekends were dedicated to hauling and chopping wood. A good education surely kept me out of trouble.

I hope these historical and cultural views provide an essential consideration and sensitivity towards human cultural values as we consider management of an ecosystem. An important and significant element is that we all must work cooperatively to achieve that delicate balance.

Now I would like to provide you an overview of my and my partners involvement, cooperatively with the U.S. Forest Service on the Petaca ecosystem and its management.

Obviously, things have changed dramatically from the historical overview I just presented. For one, the economic situation and its impact is dramatically different and so is the transportation and communications systems. Research information and management approaches present new opportunities and challenges.

Our Petaca watershed involvement is known as the Cerro Azul grazing allotment. This allotment consists of 22,000+ acres and is located at the southern end of the watershed. A major element of our association uniqueness is the approach. We function as an incorporated association with a grazing permit from the Forest Service, Bureau of Land Management, and State of New Mexico.

The Cerro Azul grazing association has been operating in its present form for twenty five years and we all consider the operation a success. Following are some of the accomplishments on this allotment during this period:

First and foremost is the partnership arrangement that has evolved between the Association and the Forest Service, particularly, both in investment and management decisions. This cooperation has been evident since the Association was formed.

This allotment was changed from sheep to cattle. Some of our neighbors still run sheep on their allotments.

On-the-ground improvements include:

- Establishment of a rest-rotation grazing system.
- Construction of approximately twelve miles of boundary fences and eight mile of cross fences.
- Rehabilitation of fifteen stock tanks with plastic to retain the water, a critical resource.
- Development of a well and pipeline extension of approximately twelve miles and two water storage tanks. Also, a water catchment.
- Installation of five cattleguards to accommodate public traffic with minimal livestock impact.
- Construction of two livestock corrals.
- Acquisition of association-owned management equipment, and more importantly,
- A working range improvement and livestock management system conducive to the range and our livestock enterprise.

The Forest Service also did extensive range improvements including piñon-juniper control and range revegetation. A tree crusher was used in eliminating piñon-juniper, to allow for the planting of crested wheatgrass. The piñon-juniper was cut to firewood length, which served the surrounding communities with their wood supply for a few years.

You should also know that an elk herd is increasing in this area, benefitting from our water developments. There are wood haulers and a continuing public use of the land resources within our allotment.

We continue to participate with neighboring allotments as needed and are participating on the Petaca Watershed ecosystem management approach initiated by the Forest Service - Tres Piedras Ranger District.

I cannot over-emphasize the cooperative management approach developed between the land management agencies and the resource users. Our partnership has maximized the sustained use of available resources to all parties. We know it is practical, it leads to success, and we recommend the partnership approach.

INTEGRATED RESOURCE MANAGEMENT

By Brett Coleman

We have discussed ecosystem principles and ecosystem management. Our partners have given insights into how important this area is to their cultural and social values.

We will give an overview of the process we used in assimilating these concepts and values into a vision of the future. In the Region 3 of the Forest Service, we use a process called Integrated Resource Management. This process is comprised of four steps, which are, location of an area, existing conditions, desired conditions, and possible practices.

In determining the location of the area to implement ecosystem management on, we considered various factors. Watershed boundaries were examined. The Petaca watershed was felt to be too large an area for our first attempt at implementing ecosystem management. We decided to divide this watershed into an upper and lower unit. The lower watershed basin represents a sixth order watershed.

Watershed conditions were looked at utilizing information from the general ecosystem survey. They ranged from satisfactory in the upper watershed to unsatisfactory in the lower watershed.

A wide spectrum of cultural and social values exists in the watershed. In the lower watershed, most users are local residents representing the American Indian and Hispanic cultures. In the upper watershed, forest users are generally non-residents representing more of the Hispanic and Anglo cultures.

A high diversity of soils, vegetation, elevation, and aspects were represented, especially in the upper watershed. In the lower watershed, a low diversity of soils, vegetation, elevation, and aspects are present.

Activities and uses were more varied in the upper watershed. In addition, we examined our current Forest Plan direction for this watershed. The direction did not seem to meet our idea of ecosystem management, especially, the lower watershed area. We also needed to revise our grazing management plans in this lower area.

Using these criteria, we divided the watershed into two parts, and chose the Lower Petaca as the area for an ecosystem demonstration project.

Our next step was to describe the existing conditions. To assist in this, we acquired a computerized geographic information system. This geographical information system was able to visually show the existing conditions for watershed, vegetation, streams and roads.

The general ecosystem survey information indicated that 40% of the area was in unsatisfactory watershed condition. Vegetatively, the area was comprised of 44,604 acres of piñon-juniper, 32,528 acres of sagebrush, and 18,985 acres of revegetation. Revegetation is defined as the manipulation of either piñon-juniper or sagebrush to a crested wheatgrass vegetation type. The area has no perennial streams. Water is present in drainages only during snowmelt, as seen here, and rainstorms. Streams are ephemeral and riparian acreage is less than one percent of the area.

Roads in the area are mostly primitive and not maintained. They have been created by forest users to meet their need, with no consideration for other resources. There are over 150 miles of road in this area. The lack of road engineering and maintenance has lead to most of these roads contributing to the soil erosion occurring. These roads receive traffic use year-round due to the low precipitation (12-16") that falls.

Elevations are mostly from 6800 feet to 7600 feet, with old cinder cones being higher. The aspect is mostly southerly and slope is mostly under 5%.

Wildlife present are mostly elk and deer, with prairie dogs, rattlesnakes, jackrabbits, and foxes comprising the small mammals. Raptors and neotropical migrant birds inhabit the area. A sensitive plant species, Ripley's milkvetch (*Astralagus ripleyii*), is native to the area.

Existing activities and uses in this area are cutting piñon-juniper for fuelwood and fence posts, grazing of cattle and sheep during the fall, winter, and spring months, collecting piñon nuts, hunting, and gathering of forest products by American Indians. Artists gather cedar posts for carving, sagebrush for prayer sticks, and paint the spacious vistas. Some landowners have homes on their private land within the area. Two housing subdivisions are being developed, while two to four more are being planned in this area.

Existing cultural and social values are dependent on the products that this area produces. Area residents are able to sustain their livelihood through these products, which allows them to maintain their cultural values. Area residents have been here for numerous generations. They have a deep attachment for the land. It has allowed them to choose to remain in this rural way of life, with its slower pace and more friendly atmosphere.

The third step was to describe the desired conditions for this area. Using integrated resource management, there are three parts to the desired condition. These are quality of life, activities and uses, and landscape. None of these parts is more important than the next. To better understand and describe the desired conditions, we actively sought public involvement.

We asked our partners and interested publics to attend field trips and meetings. These were to see the existing conditions and have discussions concerning the desired conditions. We wanted people to get an opportunity to meet one another and exchange thoughts. Numerous people attended these, including the Taos Pueblo Indians, grazing permittees, environmental group leaders, Bureau of Land Management, New Mexico State extension personnel, and private landowners within and bordering the area. We also had trips for Forest Service employees from all levels of the

organization. In addition, we talked to numerous individuals who had knowledge of the area and asked their thoughts and comments.

For the quality of life desired conditions, a major change in planning occurred. More often than not, we ignored social and cultural implications of these planning decisions. We measured decisions in quantifiable ways, such as jobs and economics.

We described three land ethics, representing the three cultures involved in management of this area. These land ethics reflect the social, spiritual, religious, and caring that these cultures have for this area. The Taos Pueblo Indians feel free to gather and use plants and animals for religious, traditional and medicinal purposes with few bureaucratic restrictions. The Spanish land ethic is that the land is here to serve the needs of the people within judicious use. The Anglo land ethic is concerned with the health of the forest and want to ensure it is here for their children and grandchildren to use and enjoy.

Our desired condition for partnerships was to strengthen them with existing partners and seek out new partners. We bring neighbors together to discuss ecosystem management. We desire that everyone continues to listen, accept responsibility, respect one another, be honest, and above all, continue the dialogue. People are informed, educated, and participate in project planning, analysis, implementation, and monitoring. We will continue to consult and cooperate with our grazing permittees, Taos Pueblo Indians, private landowners, and other forest users. We have joined with the New Mexico State University Extension Office to study piñon-juniper regeneration.

The second part of our desired conditions for this area was activities and uses. Within the sustainability and productivity principles, we will be continuing these activities and uses.

Most people agreed that a well-functioning watershed and productive soils are the basic components from which their enjoyment and use of the area are derived. Reducing the number of roads was one way of meeting the needs of the watershed. Other activities and uses were firewood, livestock grazing, recreation, gathering piñon nuts, gathering forest products for artistic endeavors, hunting, and others. We recognize that ecosystems are dynamic and we do not have all the answers.

Describing the landscape was the third part of the desired conditions for this area. There is less sheet and rill soil erosion, existing arroyos are healing and fewer, new arroyos are being produced. More reliance on native vegetation, rather than introducing or maintaining non-native vegetation, and a greater diversity of native vegetation is desired. Roads are planned, managed, and maintained. Wildlife populations are sustainable within the capacity of the land. A wide diversity of species, age, and numbers are present within the area. Threatened, Endangered, and Sensitive plant and animal species have increased in frequency and density so that they can be removed from their special designation.

These three parts complete our description of the desired conditions for the Lower Petaca ecosystem management unit. We have now described the existing and desired conditions. The differences between these two conditions means change must occur. This leads to our fourth step, identification of possible management practices that will move us toward our desired condition.

In some instances, the management practice may be to let nature take its course. An example is in the revegetation areas. In some of these areas, reductions in crested wheatgrass density and frequency are occurring while the native grasses and forbs are increasing. We will continue to let this happen, knowing that our desired condition will take longer to reach.

In most cases, a management treatment is appropriate. To improve the condition of the watershed, changes in existing management may occur, along with special projects to improve the condition of the watershed. The type of change that needs to occur determines the various methods or tools that we can use. We have a variety of tools available to use, such as road closures to reduce the number of roads and prescribed fire and livestock grazing to change the vegetation. Other tools range from pesticides to applications of treated sewage.

These are brief descriptions of the four steps that we have gone through on our path to ecosystem management. These were locate the area, describe existing and desired conditions, and possible practices.

CARING FOR THE LAND AND SERVING PEOPLE

Amigos, as we implement ecosystem management we must think in terms of larger landscapes, such as entire watersheds, and longer timeframes over several hundred years. Ecosystem management is a concept where you must balance the needs and values of people with the long term care of the environment. What we have presented here is the Southwest Region, Integrated Resource Management Process, the Road to Ecosystem Management. The process must be tailored to your individual area or project. The Lower Petaca Ecosystem Project is successful because we have built understanding, trust and credibility with a diverse group of people. I firmly believe the time spent working with people is well worth the effort.

As Brett Coleman discussed, the first step in the process is to locate the area and define the boundaries of the ecosystem. Second is to define existing conditions. This is an area to be careful with. You will never have all the information you want and it is easy to fall into the trap of inventory, the gathering of detailed information on every soil, plant and animal. You as a resource manager, must manage this process. Third, you need to define your desired conditions. This is where public involvement, with field trips, presentations, discussions and debate will help you to define the three parts of Desired Conditions:

- Quality of Life, the relationship of people to the land, their land ethic.
- Activities and Uses, how to people use the land and what do they need.
- Landscape, the physical, biological, and ecological appearance of the land.

Fourth step in the process is to list what practices and projects will help move you closer to desired conditions. Once you know where you are going, take every opportunity to get closer.

Compañeros, a reality check is in order here. Ecosystem management is expensive. Do not expect an unlimited budget to accomplish everything that needs to be done. Do not expect tp get their overnight. Manage the resources under your control, workforce, budget, and forest users to move closer to desired conditions. Look for partnerships wherever possible to make your limited budgets stretch farther. Use the best information available. Incorporate research where possible.

Try to work smarter, not harder. In this age of information and technology, you must set priorities. As the Chief of the Forest Service, Jack Ward Thomas directs us: Obey the laws and tell the truth.

Some people have told me that the Forest Service should let nature take care of itself, that we should eliminate all grazing, logging, firewood gathering, even recreation. They tell us to turn our forests into National Parks or wilderness areas. Do not believe them. The mission of the Forest Service, as directed by Congress, is to care for the land and serve people. Resources must be managed, harvested, and utilized according to ecological principles to ensure continued outputs and sustained yields for today and future generations.

Ecosystems are dynamic and characterized by constant change.

Remember, even doing nothing has an effect on the ground. You can write the best reports and plans on paper, but what is most important are the effects on the ground as the project is implemented. The Petaca area is a storehouse of resources that can be used in a wise way to meet the needs of people. Perhaps not all needs or wants can be satisfied, however, provide what you can sustain over the long term.

I am proud of the existing partnerships with grazing permittees like Palemon Martinez of the Cerro Azul Grazing Association. The allotment is achieving the desired results on the ground. I am proud of the interest and support our neighbors and partners like Mark Lujan from Taos Pueblo have shown in the project.

I am also proud of of a research project on Piñon-Juniper Regeneration with Dr. John Harrington of New Mexico State University that will provide land managers like myself with information on sustainability of Piñon-Juniper firewood harvests.

I am also encouraged by a potential partnership with the Rocky Mountain Elk Foundation and Livestock Grazing Associations to jointly study and improve habitat for elk and livestock in the Piñon-Juniper and sagebrush-grassland ecosystems.

What we have learned in the Lower Petaca Ecosystem Project is people share a higher value. This value is a healthy, productive, watershed with a good ground cover of vegetation, litter and rocks, to protect the soil from water and wind erosion. A watershed in good condition supports a wide diversity of native vegetation and wildlife. From this productive, diverse, resource base will flow many goods and services that are sustainable and available to meet peoples needs and values.

It does not matter where you live and work, people have a relationship to the land. You need to respect these feelings, values, and needs. People need to know you care, after all, they are the owners of the National Forests and have entrusted them to us to manage.

Companeros, just like Aldo Leopold said, you need to climb a high ridge, leave without pay, and take a look around. What we have shown in this presentation is the U.S. Forest Service, Southwest Region process for sustainable ecosystem management. I challenge each of you personally, to get involved, to study, to learn more about ecosystem management. These truly are exciting times. Ecosystem management is an evolving process and we must continue the dialogue with our neighbors from Mexico, and partners like Palemon Martinez and Mark Lujan. We are on the same journey together.

You will know you are successful when you have improved the resource conditions on the ground and helped even one person, maybe to get a load of firewood for the winter from a forest that needs to be thinned out, or to help an artist find a dry cedro to carve santos that he will sell to feed his family, and no one knows but you.

That is what I call "Caring for the Land and Serving People."

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Management, conservation, and protection of forests in Desierto de los Leones Forests

Jesús Vázquez Soto[1]

Abstract.—This paper analyzes the management, conservation, and protection of the Parque Cultural y Recreativo Desierto de los Leones (PCyRDL) in relation to forest vegetation, its health, and its decline. The silvicultural practices are revised in order to find those with good results based on forest inventory data. A management plan is presented, considering the forest pests and diseases, sanitary conditions, the phenology, the natural regeneration, the environmental requirements, vegetation mixtures, tree diameters, diversity of floristics, conservation, seral phases, and underground water. In 1986, the benefits of such a plan were observed when forests produced not only vegetative growth but also an important amount of seeds. Such results demonstrate the positive reaction of these forests to treatment.
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The technical and social basis for implementing the master plan to manage the Patzcuaro Watershed—"INIFAP-INI Subcomite de Solidaridad"

Alberto Gómez Tagle Rojas[1], Yolanda Chávez Huerta[2], Carlos Sánchez Brito[3], Ramón Claverán Alonso[4], Manuel Trejo Sánchez[2], Gilberto Chávez León[2], Juan Mena Chavarría[2], Araceli Orbe Mendoza[5], Sergio Castillo Orta[2], Constantino Orduña Trejo[2], Alfredo Luis Aguilar[2], Rubén Heredia[6], José Luis Ávalos Lemus[7], and David Maldonado Sánchez[8]

Abstract.—The National Forest, Agriculture and Animal Husbandry Research Institute, National Indigenous Institute, and the Regional Center of Fishing and Solidarity Subcommittee for the Pátzacuaro and Zirahuén watersheds collaborated to gather information and experiences that allowed them to form a management plan. Based on field research, literature review, social research, and statistical and cartographic studies from GIS systems, a data base was generated that indicates the following:

1. The production systems used in this watershed were good at one time but now they are causing much deterioration. Production technologies should be renovated.
2. The present population is 78,475 of which 24% is indigenous.
3. The GIS model shows options for recuperating the watershed within 3 to 15 years.
4. The agricultural practices have generated different erosion levels. Per surface unit, overgrazing is the most erosive activity.
5. Overgrazing must be controlled.
6. Fishing must be controlled to avoid species extinction.
7. It is urgent to support soil conservation, reforestation, and the control of pollutants in both urban and rural areas.

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Partnerships for sustainable forest ecosystem management in the Lake Tahoe Region

Steve W. Chilton[1]

Abstract—The Tahoe Region is a special place. It was once a place of unspoiled beauty. Yet, like other natural places, its beauty has been compromised. The progress of modern life has diminished the unique values that make the Tahoe Region so extraordinary. With ever-increasing pressure on the Region as a recreational resource and urban center, preservation of the values of the Tahoe Region is vitally important and immensely difficult. Restoration of those values lost over time seem impossible. Management of the forest ecosystem has only recently become a priority.

During the silver boom and the western migration of European settlers in the 1800's, almost the entire forest stand of the Region was logged to obtain timber and fuel for the Comstock mines. Today, the forests of the Region are extremely unhealthy, partly because of the clear-cutting of that era and the fir-dominated forest that sprang up afterwards, and partly due to highly successful fire suppression policies.

The mission statement of the Tahoe Regional Planning Agency (TRPA) is:

> *The Tahoe Regional Planning Agency leads the cooperative effort to preserve, restore, and enhance the unique natural and human environment of the Lake Tahoe Region.*

This charge encompasses many goals and challenges, including establishing partnerships for sustainable forest ecosystem management. In October 1992, the TRPA established the Forest Health Consensus Group, a public partnership between interested citizens, and private and public agency natural resource specialists. Evaluation of forest management and assistance to the general public and decision-making bodies on the current and long term dynamics of the forest ecosystem by looking at the Tahoe Region forest ecosystem as a whole are the key tasks of the Group. The Group has defined the Desired Future Conditions of the Lake Tahoe Region Forest Ecosystem, primarily restoration to its condition prior to the arrival of European-American settlers in the mid-1800's.

These "Pre-European Settlement Conditions" are defined in terms of broad forest vegetation types which predominated throughout the Region. The descriptions serve as general targets for land managers to re-establish forest health in the Lake Tahoe region and represent a mosaic of states encompassing a range of characteristics occurring in time and landscapes.

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HISTORY AND BACKGROUND

The Lake Tahoe Region is a special place. It was once a place of unspoiled beauty. Yet, like other natural places, its beauty has been compromised. The progress of modern life has diminished the unique qualities that make the Region so extraordinary. With ever increasing pressure on the Region as a recreational resource and urban center, preservation of the qualities of the Tahoe Region is vitally important and immensely difficult. Restoration of those qualities lost over time seem impossible.

The history of the Lake Tahoe Region over the last three decades is a history of controversy. Disputes have arisen over a variety of individual issues, zoning, growth, development, federal intervention, property rights, and recently the health of the forest ecosystem, but virtually all of this disagreement can be traced back to a single, simple truth that almost no one disputes. In terms of clarity and purity, the waters of Lake Tahoe are unrivaled. Only one other large lake in the world, Oregon's Crater lake, contains water as clear as Tahoe's. This remarkable clarity, combined with Tahoe's mountainous, subalpine setting, makes for an area of remarkable scenic beauty.

Located between the Carson Range on the East and the Sierra Nevada on the West, the Tahoe Region straddles the California-Nevada state line. About two-thirds of the Region is in California. The total land area is over 207,000 acres, with about 75 percent in public ownership. Lake Tahoe is the dominant feature of the region and is world renowned for its clear waters, size and beautiful setting.

A History of Conflict

It is important to acquaint the listener with some of the history and conflict inherent to the Lake Tahoe Region. Collaboration and partnerships have been key to overcoming barriers and reaching solutions. From the past to the present, the Lake Tahoe Region has been a battleground of new ideas and pressures meeting familiar, established ways.

The Tahoe Region was once home to the Washoe Tribe. The Washoe people lived around the shores of Lake Tahoe during the summers, fishing the Lake and gathering food in the surrounding forests. Today, after much abuse, Washoe cultural sites are protected to preserve what remains of this important part of our heritage.

During the silver boom and the western migration of European settlers in the 1800's, almost the entire region was heavily logged to obtain timber and fuel for the Comstock silver mines near Virginia City, Nevada. Today the forests of the Region are extremely unhealthy, partly because of the clear-cutting of that era, and the fir dominated forest that came back after the logging.

For many years after the turn of the century, the Tahoe Region served a small number of residents and tourists; access was difficult. Most development and urbanization of the Region occurred after the Squaw Valley winter Olympics in 1960. Since that time, the population of the Region has increased over five times, with about 80 percent of the population residing in the California part of the Region.

Today, the year round population is about 52,000. Peak summer day population, including day use visitors, is about 250,000 to 300,000. There are about 20 developed towns and communities. The City of South Lake Tahoe is the only incorporated city. The Region is home to approximately 24,500 single family homes, 14,100 multifamily units, 12,000 tourist accommodation units, 2,115 campground units, and about six million square feet of commercial floor area.

Casino gaming areas are located in Nevada, at the north and south stateline areas, and in Incline Village. Casinos have played a key role in changing the dynamics of the communities that existed fifty years ago. They are also responsible, much to their regret, for setting the stage for budding environmental groups maturing into powerful forces that can not be ignored. These groups were able to force legislation that effectively curtailed expansions of existing casinos and eliminated the possibility of new ones.

The undeveloped areas of the Region are predominantly publicly owned and managed by the U.S. Forest Service, the Nevada and California State Park Systems and State Lands Commissions. Outdoor recreational use of the Region is extensive and ranges from boating to skiing. Both dispersed and organized recreational activities abound.

Long Term Environmental Trends

Long term environmental trends provide insight into both the challenges facing the Tahoe Region and the effectiveness of environmental control programs. Some of the most critical trend information include air quality, water quality, transportation, economic indicators and forest health.

Let's start with air quality. The air quality in the Region has been improving, primarily due to the integration of a cleaner vehicle fleet mandated by federal and state vehicle emission standards.

Water quality is another story. Since 1968, algal productivity in Lake Tahoe has increased over 300 percent. During the same period, the clarity of the deep pelagic waters of Lake Tahoe has decreased, on the average, more than one foot per year. Waters of the shallower littoral zone of Lake Tahoe also show evidence of increasing algal productivity. Lake Tahoe is undergoing cultural eutrophication, which occurs when influences of civilization result in imbalances in a lake's nutrient budget, accelerating natural increases in algal productivity.

Despite large public and private investments in water quality in the last 25 years, the water quality trends in Lake Tahoe will continue until the nutrient budgets can be brought back into balance.

This will take many years, under any management and control strategy. Given undisturbed conditions, Lake Tahoe would be expected to change so slowly that the changes would be imperceptible over a human lifetime. Private and public people have found a commonalty with the people of Lake Baikal in South-Central Siberia. Lake Baikal, the world's largest lake by volume, holding 20% of the Earth's liquid fresh water, is experiencing strong development pressures and reductions in it's clarity. The Tahoe/Baikal Institute was established in 1990, sponsoring student exchanges between the two areas for the purpose of environmental education and awareness and local communities have established sister city relationships with communities surrounding Lake Baikal. Lake Tahoe hosts at least five delegations of Russian visitors from the region each year anxious to learn solutions for integrating development with protection of natural resources.

Transportation has been a dilemma for many years. Strong coalitions have formed and are working to become more efficient and resourceful in securing funding to improve and in some cases, completely rethink transportation as it has been approached in the past.

The economy of the Region has felt the effects of the recession as have most communities in the country. Being primarily a recreational resort area, providers have recently recognized the powerful linkages between environmental concerns and continuing profits. These providers, ski areas, marinas, casinos and federal and state recreation areas have formed a partnership to prioritize needs and to jointly seek solutions.

The last environmental trend and one that immediately threatens most of the others is the severe decline of the health of the forests of the Region. The Lake Tahoe Region first attracted the attention of the early settlers not for its water, but for its trees.

The discovery of silver in the Comstock Lode near Virginia City, Nevada in 1859 created a large demand for lumber. As forests in the Virginia Range, near the Lode, were depleted in the years after 1860, area logging companies began moving their operations up into the Lake Tahoe region. Not less than 80 million feet of timber were consumed annually on the Comstock Lode. One mine alone used six million feet a year for mine timbers. That same mine also consumed 250,000 cords of wood annually to power hoisting works and pumps.

Lake Tahoe is dominated today by overly dense, fir-dominated forests that are vulnerable to drought. Nutrients in soil and available moisture will only support one healthy tree for every three which now grow. The inevitable result of this over stocking has been tree disease, insect infestation, and tree death. Throughout the Tahoe region, approximately 25 percent of the trees are dying. In some places, mortality runs as high as 60 to 80 percent. The cause of the unusually high tree mortality has been ascribed to a bark beetle infestation brought on by the first five years of the current drought. Roots of the problem go back over a hundred years when Lake Tahoe's forests were clear cut to provide for those silver mines of the Comstock Lode. This deforestation led to replacement of natural old growth forest with new stands of trees which began to grow in the late 1800's. Now that thousands of young pine and fir trees of the late 1800's have matured, most forests are overstocked.

Past Problems and Solutions

Land use and growth regulation has been a factor at Lake Tahoe since 1913 when the first association concerned with growth was formed. Environmental problems, combined with a governmental structure that stifled partnership formation because of apathy, turf wars, narrow focus and reluctance to change created a climate for intervention by the two states and the federal government. In 1967, a commission established by the California and Nevada legislatures found that:

The clarity and purity of Lake Tahoe's waters, as well as the beauty and amenity of the Lake Tahoe watershed itself, continues to be threatened not only by still unresolved problems of sewage treatment and disposal, but more particularly by inadequately controlled land uses.

It has proven to be infeasible for the existing system of 61 overlapping governments in the Tahoe Region, and for the two states acting independently, to administer the affairs of the Region in the interests of all concerned.

In reaction to these early problems of uncontrolled growth and sewage treatment, and as the result of a tenuous partnership between environmental and development advocates, the Tahoe Regional Planning Agency was established with the primary goal of developing a comprehensive master plan for the Lake Tahoe Region, including setting Environmental Threshold Carrying Capacities and developing a set of Best Management Practices. The historic Bi-State Compact, a one of a kind document, was then signed by then California Governor Ronald Reagan and Nevada Governor Paul Laxalt. The U.S. Congress and President Richard Nixon then signed the Compact into federal law on December 19, 1969.

The Bi-State Compact made many findings, including these most important elements:

a) The waters of Lake Tahoe and other resources of the Lake Tahoe Region are threatened with deterioration or degeneration,

b) The region exhibits unique environmental and ecological values,

c) The region is experiencing problems of resource use and deficiencies of environmental control,

d) Increasing urbanization is threatening the ecological values of the region,

e) Maintenance of the social and economic health of the region depends on maintaining the significant scenic, recreational, educational, scientific, natural and public health values provided by the region,

f) There is a public interest in protecting, preserving, and enhancing the values for the residents of, and visitors to, the region,

g) In order to preserve the scenic beauty and outdoor recreational opportunities of the region, there is a need to insure an equilibrium between the regions natural endowment and it's man-made environment,

h) It is imperative that there be established a TRPA with the powers, among others, to establish Environmental Threshold Carrying Capacities and to adopt and enforce a regional plan and implementing ordinances which will achieve and maintain such capacities while providing opportunities for orderly growth and development consistent with the Thresholds.

Since that time the Compact has seen significant revisions. It continues to be the founding document for the authorities and directions of the TRPA.

As required in the Bi-State Compact, on August 26, 1982 TRPA adopted Environmental Threshold Carrying Capacities to protect the values of the Region. These thresholds were the result of many meetings with public and private interest groups and technical advisory committees from all sectors of the public and private arenas. The thresholds are achieved and maintained through implementation of TRPA's regional plan. Much of what TRPA does is driven to attain and maintain the thresholds.

While "partnerships" was not a term of the time in the 70's and 80's, it was a major reason for the success of these endeavors. Using technical advisory committees, these partnerships blended the knowledge and needs of private and public groups, overcame institutional and legal barriers, and forged far-reaching standards for the Region.

The Compact defines "environmental threshold carrying capacity" as an environmental standard necessary to maintain a significant scenic, recreational, educational, scientific or natural value of the region or to maintain public health and safety within the region. The thresholds include standards for air quality, water quality, soil conservation, vegetation preservation, wildlife, fisheries, recreation, scenic resources, and noise.

On the ground application of environmental controls was haphazard to non-existent prior to 1980. In some areas the technology had not been developed for use for such project specific needs. To uniformly guide engineers, architects and land managers, a hand book of best management practices (BMPs) was developed utilizing technical advisory committees of local, state and federal personnel. Best Management Practices is a term used to denote resource management practices whose purpose is to maintain water quality and to prevent or minimize water quality impacts. TRPA policies and ordinances require that water quality considerations be incorporated into the design and execution of any land use activity in order to prevent water quality degradation. Prevention is achieved through application of project-specific protection practices, which are the result of technical advisory committee (TAC) recommendations.

The application of BMP's generally follows a four-step process :

1. **BMP Planning**—At an early stage in the development of the project plans, possible water resource issues, concerns, or opportunities are identified. BMP's are selected which address resolution of those concerns.
2. **BMP Project Planning**—Working with other resource specialists or consultants, site specific prescriptions are developed for the selected BMP's. Specific measures will depend on water quality standards and existing or proposed beneficial uses.

   These prescriptions are then included in the project plan, contracts, and design specifications. These BMP prescriptions may be included as development requirements and constraints or mitigation measures associated with a given alternative.
3. **BMP Application**—This part of the BMP process includes the actual on the ground implementation of the project's water quality protection measures. Responsibility for application normally lies with the contractor, the Compliance Division of TRPA, and the appropriate county or agency inspectors.
4. **BMP Monitoring and Evaluation**—This is the final step in the BMP process. Monitoring and evaluation assures that water quality concerns are evaluated, BMP's considered, and applications are effective in responding to the concern. For example: Were the appropriate BMP's included in the plan or project formulation? Did execution of the plan or project follow agreed upon direction? Monitoring also helps determine how effectively BMP's protect and or improve water quality.

BMP's are utilized on the smallest to the largest projects; from residential development to dredging, from forest management to highway projects. How does this impact the normal person, wanting to upgrade their home?

BMP's have become a part of all construction and activities in the Tahoe Region and have proven to have positive affects on site as well as off-site. The individual property owner has, sometimes over their objections, become a partner in protecting and restoring the Region's ecosystems.

RESTORATION OF THE FOREST ECOSYSTEM

Protection and restoration of the forest ecosystem are inherent products of the Bi-State Compact, the Thresholds, and BMP's.

As the umbrella government organization with the responsibility for review of all projects that may have an environmental impact upon the Region, the Tahoe Regional Planning Agency was the logical sponsor in the formation of a partnership between the private and public groups concerned with the health of the Region's forests. The partnership became known as the Forest Health Consensus Group.

When the Forest Health Consensus Group was formed at Lake Tahoe in October of 1992, it wasn't difficult to see that many of the trees in our forests were in bad shape. For three or four years, trees of

all sizes had been dying all over the Tahoe Region. This widespread tree die-off led to the recognition by interested citizens and government personnel, including the Tahoe Regional Planning Agency, that Tahoe's forest health was declining. In an effort to begin restoration of the forest, the TRPA adopted a number of amendments to its Code of Ordinances which facilitated forest management projects. From discussions surrounding changes to the "Code" came a realization that the direction of forest management in the Lake Tahoe Region needed to be evaluated.

Interested citizens and natural resource specialists have met formally as the Forest Health Consensus Group in an effort to discuss and resolve the many problems plaguing our forests at Lake Tahoe. Much of Lake Tahoe's forests of mature Sugar, Jeffrey, and Ponderosa Pine were removed for Comstock Lode mining and replaced by even aged stands of Pine and White Fir. In addition, fire exclusion, lack of selective thinning and above average rainfall produced a forest with a dominance of fir over pine and an increased density of trees.

The Forest Health Consensus Group constitutes a wide spectrum of people interested in the extremely complex subject of the health of our forests in the Lake Tahoe Region. Composed of loggers, federal, state, and local agencies, environmental groups, the Regional Fire Chiefs Association, college professors, forest products industry representatives and citizens, the group shows a great depth of understanding and education on the subject.

Our meetings have been well attended, averaging 20 people, and we have been fortunate in securing the services of professional facilitators from the University of Nevada Cooperative Extension.

The Forest Health Consensus Group has recognized that an accelerated and safe transition from today's unhealthy forest to a healthy forest is complex, requiring vision and commitment from all those concerned.

Given the diverse points of view on the subject, reaching consensus on an issue as complex as the long term management of the forests at Lake Tahoe has been a lengthy process. I believe that if only TRPA staff or TRPA staff and Forest Service staff met to hammer out the plan for long term management, including changes in regulations, the process of legal challenges would be only beginning. It is true that in the long run it is often quicker to go slow and involve all players than to move quickly and limit involvement until it is public hearing time. The end result may not be very different, but the length of the process is.

The mission of the group was one of the first items of business the group tackled. The mission is to recommend to the TRPA Governing Board changes to the TRPA Regional Plan regarding the forest ecosystem. An important element of that is education of ourselves, decision making bodies, and the general public on the Tahoe Region Forest Ecosystem. The Forest Health Consensus Group sees the condition prior to the arrival of European American settlers in the mid 1800's as the target for restoration. After that time, many impacts associated with the uncontrolled clear-cutting that occurred in connection with Comstock mining, including tree disease, beetle infestation, fire hazards, and fire exclusion have created the massive forest problems we see today. We have defined Desired Future Conditions of the Lake Tahoe Basin Forest Ecosystem and call the product "the green sheet".

The "green sheet" includes seven forest vegetation types. It may take many years of careful management of the forest ecosystem to attain these forest conditions. The Desired Future Conditions serve as general targets for land managers in their efforts to re-establish forest health and represent a mosaic of states that encompass a range of characteristics that occur through the variation of time and landscapes. Our goals include a gradual return to proportions of age classes, including old growth stands that approximate pre-comstock logging levels. This goal includes recognition of the need to retain and foster stands which exhibit, or which may easily attain old growth characteristics such as large, heavy limbed, broad crowned, or very tall trees.

Our mission was to guide restoration of the forests to the condition found in the early 1800's. But, how do we know what these conditions were? There is no one here to provide a live accounting of those conditions. We have worked for over a year to research this ancient forest through pioneer's historic accounts and descriptions of other early settlers such as Muir and Brewer who

saw the forest before it was logged. An early written account by John Muir in 1894 described unlogged areas around Lake Tahoe as open and park-like where a man could easily ride a horse through groves of enormous pines. We have also studied the current forest for its species types and composition. In some instances, 100 year old tree stumps from the Comstock mining days have been discovered and studied by specialists in tree growth rings. Evidence indicates that in many parts of the Tahoe Region, large mature trees were widely spaced, and intermixed with individual younger trees, of various ages.

The forest floor too, was more open, with less brush and fewer downed trees to impede walking. In many cases, the forest floor was opened up by the relatively frequent, about every eight to ten years, low intensity, understory fires that didn't destroy the forest itself.

We have often asked ourselves, "If our forests are continually changing, then how can a particular desired forest type be perpetuated?" Setting it aside to preserve it "as is" will not work, given the other activities such as fire suppression. One way to maintain a particular type of forest would be to have it exist at different locations scattered across the landscape. Given the natural evolution of plant communities and disturbances such as fires, diseases, windstorms, avalanches and floods, the desired forest type will appear and disappear as time passes. However the desired forest type would always exist somewhere in the landscape, although never in one spot permanently. What would exist would be a shifting mosaic of forest types or other plant communities across the landscape.

HOW DO WE CREATE A MOSAIC OF FOREST TYPES?

A mosaic of different plant communities currently exists in the Lake Tahoe Region. However, some types are under represented and some are over represented. There are not many old growth stands, yet there is an abundance of mature pine and fir. If the desired condition is to have more old growth pine and less mature pine and fir, one way is to wait and hope this will come about without human guidance. Another approach would be to manipulate the forest in order to accelerate and guide the change towards the desired condition. Neither approach guarantees the desired conditions will be achieved. However, by thoughtfully and deliberately working towards a defined goal or state, success should be more likely, using a variety of strategies, some which will involve active management and some which will no doubt include leaving it alone.

The restoration of forest health may include wildlife habitat improvement, the reintroduction of fire as a management tool, a reduction of the impacts of undesired fires, and fire hazard reduction in the urban area, wildland interface, and in backdrop areas of the Region. But the Consensus Group is not a single interest group such as fire hazard reduction.

Fire hazard reduction occurs as a consequence of the overall strategy of managing for forest health. Individual citizen groups throughout the Region are focusing on defensible space and other fire hazard reduction techniques and many of those people are also partners in the Consensus Group.

Reaching consensus on forest health is a continuing voyage, not a single event to be completed or a destination to be achieved. It is an evolving process that must have rules to assist in channeling the vast amount of energy people bring to it. One of the early dilemmas the Consensus Group was faced with was partners within the group fallaciously using their membership in the group to bolster their positions or to torpedo the efforts of the group, primarily by using the media, and it is an obstacle that continues to exist today. Early in the Group's tenure, rules of conduct were agreed upon.

Among those was that no member would use the media to torpedo the group or to take credit for the work of the group as a whole. This has been abused by some members, but to the credit of the majority, it has not become the wedge that could have spelled the demise of consensus. Something I have learned is that I cannot speak as a spokesman for the Group, but only as a member of the group.

If I could give a group of concerned agency or private individuals contemplating beginning a similar partnership approach three pieces of advice, they would be:

1. Identify and include all interested people. If you leave some out, they will attend anyway, and the atmosphere of openness and cooperation will be tainted.
2. As a first order of business, write up a mission statement that is agreed to by all. Without this important document, meetings will bounce along all possible tangents, leaving little time for serious discussion of the issue.
3. Be patient. Provide as much time as is needed. Schedule meetings so all can attend. It can be very difficult to match the majority of people's schedules, but if meetings are troublesome to attend, attendance will suffer and so will the effectiveness and credibility of the group. And, always keep in mind that the process of building a collaboration or partnership is only a means to a far more important end of achieving measurable change.

There are many similar partnership programs we are also involved with which focus on ecosystem management. The Sierra Nevada Ecosystem Project, the California Executive Council on Biodiversity and the President's Council on Sustainable Development are a few.

Private and public sector collaboration is very difficult. Partners in the private sector are often frustrated with the slow, but deliberate pace of consensus.

Those in the public sector are often not empowered to set policy or to speak their minds. In the Lake Tahoe Region, we are uniquely able to focus on developing a healthy ecosystem because the Region has been recognized by so many as unique and worthy of extraordinary efforts to restore and protect it. Because of its international status as a natural treasure its forests have been managed primarily to protect water quality and scenic values rather than for more utilitarian goals such as timber production and harvest. This has given land managers such as the U.S. Forest Service a direction that is more like that found in a national park and empowered those managers to seek less recognized management approaches such as Desired Future Conditions of the Lake Tahoe Ecosystem.

There remains much work to do, but the process has been successful. Citizens have become involved in guiding the restoration of a resource immensely valuable to them and to their future generations. They have realized that a partnership is a continuing voyage, not a single event to be completed or a destination to be achieved.

CLOSING REMARKS

Closing thoughts

Jerry A. Sesco[1]

In the beginning of our week, I reflected on the significance of ecosystem management as a policy and an approach to resource management in the United States—and a key element that grounds our bilateral work in forestry. At our closing, I can only share my impression that this week has been one of hearing and seeing policy in action.

We can name specific problems that we've attacked together—problems related to migratory species, to better understanding ecosystem function and global change, to improving the management of watershed, and development of forest maps. These are only examples of work that begins with research and management partnerships, and which is conducted in the context of communities for problem solving. These examples also witness to the convergence of science and policy that transcends borders.

We have heard about the importance of adaptive management that reflects an exciting and challenging acceptance that ecosystems and people, who are part of our forest ecosystems, are dynamic. Our information bases and actions must be the same if we are to balance the needs of people and protect the integrity of the ecosystem. We're learning as we go.

We have benefited from the wisdom of our speakers that results from lives dedicated to learning, and a care for people and our natural world. Some of the many quotes memorable for this week include:

- "We're part of a vortex of change, and we must learn to ride the vortex." (Tim Allen)
- "The medicine should not be worse than the disease." (Armando Caban)
- "A good manager imitates nature." (Hugo Manzanilla)

Our Letter of Intent and Memorandum of Understanding, ***our*** policy, was developed in the whirl of a vortex of change. These frameworks look to solving problems through broad partnerships, and with gentle medicine. Each rests on an appreciation of science and the art of management, for today's good and for our common future.

[1]*Deputy Chief for Research, USDA Forest Service, Washington, D.C.*

Future challenges

Adela Backiel[1]

Our two countries should be congratulated on the common achievements that have been shared and explored this week. I'd like to comment on some important features of our work together and key challenges ahead of us.

First, let me say that I've observed that the enduring friendship between our two countries has been well founded on personal relationships springing from similar science backgrounds and a shared passion for forest ecosystems and the people who depend upon them. We began the conference by hearing about the breadth and ideology of ecosystem management in our first papers, and then we progressed to the specifics of the Quintana Roo eijido. In identifying together the processes for ecosystem management, we've learned that both countries share in a value of people, science, and partnerships—the three fundamentals for ecosystem management.

Our conversations this week emphasize that we've gone from developing similar understandings of sustainable forest ecosystem management to the "how to" of ecosystem management. We've heard that it's important to develop our understandings together and to learn from each other. This does not mean that we'll necessarily practice ecosystem management in the same way.

Tapalpa was a most impressive example of "doing" and "learning" together—with an emphasis on people, adaptability, and flexibility. As pointed out by Louis Vasquez, a next step will be to move our work from small to larger scales, keeping in mind the fit of our actions with the needs of communities dependent on forests.

Much of our conversation this week has been directed at science, a key part of ecosystem management. It was good to hear and observe that our joint activities are not directed solely at forestry research, but at a true joining of research with management applications. This level of integration is highly significant since it is at the heart of ecosystem management. Our U.S.-Mexican partnership in forestry is one of the best examples I've observed of work towards that goal.

The reality that science for natural resource management is not just ecological in focus, but must also include social and economic sciences, has been a common theme throughout the week. These perspectives are enriching and ultimately essential to understanding the "why" of natural resource questions. There is no doubt that we share a concern to develop better understandings of socioeconomic trends. This intent has been borne out in our strong and productive partnership. Indeed, accomplishments reviewed at this meeting are a showcase for action that supports sound natural resource management—management that is good for people and the environment.

It's important to see our strong partnership and successes as a foundation for future action that meets many challenges:

- We must continue to develop the knowledge and skills for sound ecosystem management.
- We must continue to search for criteria by which to judge sustainability. We know what some of the indicators of forest sustainability are, but what combinations and measures do we use?
- We must be ready to address the issue of "certification." We know that accurate and workable measures of sustainability will provide the basis for certification, and that foresters and resource managers are uniquely equipped to assist with this. If we are not ready with how we would like this issue to be handled, then people other than natural resource managers will do it for us.
- Last, the U.S. goal of sustainable forest management by the year 2000 is one wherein, as a nation, we've made strides. But the United States cannot accomplish this

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goal alone. It is my hope that we will continue to work together, to the benefit of our common boundaries and common ecosystems.

We can summarize the success of this symposium with three results:

- We have progressed from talking about goals and theory to the practical application of how we accomplish ecosystem management;
- We have witnessed a successful sharing of resources and research with management techniques; and
- We have shown the strength of the U.S.-Mexico partnership.

Our work should not stop here. For all we hope to accomplish, we should guard the continuity of our efforts. It is by moving forward, together, that we can best meet the future.

One last thought. I will always remember how the term for the proceedings of the symposium has been translated through the translator as the "memories" of the symposium. What a warm way to capture the real feelings of excitement and cameraderie that this symposium in Guadalajara invoked in all of us. When we read the proceedings, we will also be cherishing the "memories" of our old and new friendships.

Thank you.

POSTERS

Water quality of the El Carrizal watershed, Tapalpa, Jalisco

Alvin L. Medina[1], Juan De Dios Benavides[2], and Esteban Talavera Zúñiga[3]

The analysis of various dissolved elements in the stream water was made to establish a point of reference for water quality, which in turn are used as indicators of the relative health and state of function of the watershed in conjunction with other physical and biological parameters. Water quality is a useful indicator of changes occurring within the watershed that are often associated with specific problems or disturbance. The objectives of this study are to:

- identify nutrients or attributes that are most significant in their response and that be used as indicators of water quality problems, and
- develop and recommend best management practices that could be applicable to problems later identified.

Water quality analyses were performed on samples taken during the rainy season of 1994. The parameters of interest included: temperature, pH, specific conductivity, dissolved oxygen, nitrates and suspended sediments. Also a complete physical-chemical and bacteriological analysis for potability of 7 selected sites was also performed in order to get a comprehensive view of other parameters that could be better indicators of ongoing processes within the riparian zone. Preliminary results show that there were no particular problems associated with some elements such as nitrates (<0.4 ppm), sulfates (5-50 ppm), total dissolved solids (54-73 ppm), and hardness (33-77 ppm), examined since they were within acceptable tolerance limits for good water quality. Turbidity (9-22 NTU) was highly variable from site to site but not particularly a problem. Iron concentrations were unexpectedly high (2.07 ppm) in the middle reaches of the watershed, and although the source remains to be identified some potential sources include mining (rock quarry), sediments from roads, or some other factor. The presence of fecal coliform bacteria (68-480/ml) also was present in all sites, probably resulting from livestock grazing within the riparian areas.

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Classification of channel types and condition of the El Carrizal watershed, Tapalpa, Jalisco, Mexico

Juan Espinoza Arechiga[1], Alvin L. Medina[2], y Alberto Gómez-Tagle[3]

A channel type classification of El Carrizal, Tapalpa, Jalisco, Mexico was done to evaluate the present condition of the watershed. The study area encompasses an area of 1284 hectares of temperate coniferous forest. Rosgen's (1994) classification methodology was used to identify channel types using such parameters as depth, width, slope, dominant sediments, confinement and width/depth characteristics. The principal channel type is the A Type, which has characteristics such as longitudinal gradient of 4-10%, a narrow (1-2.5 m) horizontal profile, well confined, and relatively with little sinuosity or straight channel. Another major type is Type B and is found in the middle reaches of the watershed. These types have characteristics such as longitudinal gradients between 2-3.9%, a wider (3-5 m) horizontal profile than Type A and with soils of colluvial or residual origin, moderately confined, and relatively low sinuosity. The other major type is Type C which is found in the lower reaches of the watershed. This type is associated with the grassland type below the conifer forest. This type has characteristics such as longitudinal gradients <2%, a wide (5-12 m) horizontal profile typical of alluvial floodplains and alluvial soils, slightly confined, and greater sinuosity. Preliminary results indicate that the majority of degradation of the riparian zone occurs in intermediate reaches, where livestock grazing, roads, mining and erosion have cumulative effects. Using this technology, it was determined that one should exercise care not to destroy streambanks that are fragile because of their erosive soils and high gradients in the upper reaches. In this cases a Type A would change into a subtype controlled by bedrock substrates, with a consequent erosional loss of soils to lower reaches and initiating a disequilibrium, a lowering of groundwater levels and water holding capacities that could ultimately result in changes of instream flow from perennial to intermittent conditions. Care should also be taken in the intermediate and lower reaches where Types B and C to maintain and enhance the riparian vegetation that augnents the relative stability of streambanks. For the lack of better management knowledge of riparian ecosystems, the stream and springs are used as cattle watering holes, roads have several crossroads, and stone quarries and road gutters deliver eroded material to the stream. It is expected that the application of this methodology (1) can be employed in different watersheds of various regions, (2) and that identification of channel conditions will permit the prediction of the behavior of the stream, (3) evaluate possibilities for restoration of the riparian ecosystem, the water, flora and fauna, and the watershed as whole, (4) develop a strategy to extrapolate management information from sites in good condition to others with similar potential.

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Ecosystem approach for diagnosis of conditions and management of riparian ecosystems in El Carrizal watershed, Tapalpa, Jalisco, Mexico

Alvin L. Medina[1], Alberto Gomez Tagle[2], Malchus B. Baker, Jr.[3], and Daniel G. Neary[4]

There is a general lack of knowledge about the importance, management and sustainability of riparian ecosystems in Mexico. Management of watersheds, as it relates to water quality and resource sustainability, is a major national concern for both USA and Mexico. A level of knowledge about riparian ecosystems exists in the USA from which strategies can be formulated into research and management models. These can now be validated on problems of common interest. The need for that knowledge, its application towards identification of causes of deterioration of riparian ecosystems, development of better management prescriptions, and the validation of existing technology, are the focal points of the El Carrizal project.

A practical application of an ecosystem management project was developed and implemented in 1993, under the 'Letter of Intent' between the USDA Forest Service and SARH—INIFAP. The primary goal was to transfer 'state of the art' technology on the restoration and management of riparian ecosystems, employing an ecosystem management approach to assessment and monitoring of the experimental watershed. Secondary objectives included: (1) to inventory, classify, and adapt rapid assessment protocols for watershed condition using vegetation, and channel types; (2) to interpret basic interactions of ecosystem components as they relate to sustainability of the resources on the watershed; and (3) to develop restoration prescriptions for the production of good water quality for the local inhabitants.

At the invitation of and collaboration with Mexican scientists from SARH INIFAP, Forest Service scientists from the Rocky Mountain Station performed a diagnosis of the experimental watershed, "El Carrizal", located outside the municipality of Tapalpa, Jalisco. Prior agreements between INIFAP and Forest Industries of Tapalpa permitted rapid implementation of plans, data collection and field work. A complete reconnaissance revealed the following major activities or disturbance on the watershed: (1) timber harvest, (2) grazing, (3) mining (rock quarries), (4) wildfire, (5) roads along streams, (6) intensive agro-pastoral systems, and (7) water diversions. Monitoring sites were selected and automated data collection systems were deployed. Concurrently, Mexican scientists were provided intensive classroom, laboratory and field training in the following areas: (1) mensuration techniques for determination of (a) water quality and quantity parameters, (b) riparian vegetation characterization and classification, (b) stream channel characterization and classification, and (d) soil erosion from road systems; (2) bioassessment techniques for aquatic systems; (3) restoration technology for forest

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road systems; and (4) applications of computerized systems for problem diagnosis. Each Mexican scientist was assigned an area of project responsibility in union with and under the guidance of a Forest Service scientist.

Collectively, all data will be carefully interpreted using an integrated disciplinary approach, such that all team members participate in the derivation of final recommendations. All data will be indexed to a GIS database which is currently being developed (Baker et. al., this issue) and used as a basis for formulation of 'Best Management Practices' for the watershed. Basic diagnostic information is being collected in the following areas: (1) rainfall, (2) water quantity and quality, (3) riparian vegetation (Medina, 1986), (4) stream channel types (Rosgen, 1994), and (5) aquatic macroinvertebrates (USDA Forest Service, 1985, and Plafkin et. al. 1989). In less than 10 months, sufficient data were collected to permit formulation of preliminary hypotheses about the condition of the watershed. These results are presented elsewhere in this publication.

The initial success of this project can not be attributed to a single person or deed, but perhaps more to the labor and belief held by all team members, that being one of "confidence in knowledgeable persons, realization of tasks, and intense desire to succeed". The gathering of many persons with special skills created an interpersonal experience that resultes in the belief mentioned above. This resulted in a type of comradery that inspired hard work and dedication to each individual's area of expertise. Every member professed a strong belief in the art and science of management of riparian ecosystems. Another important point is that this project would not have enjoyed success without the important social ingredient of "personal chemistry", an element essential to developing an effective and self motivated team.

The process of implementing this ecosystem project was largely based on Maser's (1994) philosophy of 'Adaptive Ecosystem Management', wherein Maser describes the process as one designed "for rapid and effective learning by scientists, managers, society, and policymakers and ... for rapid change". An example of how this was employed involved the diagnosis of large quantities of suspended sediments in the stream as being largely contributed from the forest roads. The technology (Burns et. al., Huendo et. al, in this issue) was available to resolve the problem, hence it was quickly deployed via field training by the scientist on actual problem areas. Managers and landowners were also informed and educated as to the problem in an effort to gain their support by committing human and natural resources to employ the technology. The expected result is a reduction of sediments being delivered to the stream, thereby improving water quality and reducing the cumulative effects on the aquatic system.

Probably one of the more important outcomes was the ability by managers, landowners, and Mexican scientists, to recognize the value of riparian ecosystems as extremely important components of watershed management. They also recognized the capacity of riparian ecosystems for producing sustainable good water quality in a region where it is a rare commodity. In addition, a clear understanding of the cumulative effects of grazing, timber harvest, and forest road construction was an important achievement towards implementing a program of ecosystem management in a Mexican landscape with intensive land uses . This knowledge developed by this product is critical for developing plans to meet the increasing demands in Mexico for a better quality of life.

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Distribution of precipitation on the El Carrizal watershed, Tapalpa, Jalisco, Mexico

Juan De Dios Benivades[1], Malchus B. Baker, Jr.[2], and Estavan Talavera[3]

A watershed was gauged in Jalisco, Mexico to study the hydrology of the area and to assist in the assessment and restoration of the riparian ecosystem (Medina et al., this issue). El Carrizal watershed is 1,284 ha in area and is located near the town of Tapalpa. With the use of a stream gauge and four tipping-bucket rain gauges, a water budget for the upper 70 percent of watershed area is being developed so the relationship between precipitation and streamflow can be determined (Baker, et. al., this issue). Two rain gages were installed at elevations of 2,065 m and 2,420 m, which are the lowest and highest gaged points on the basin respectively, and 2 others to at mid elevations on the east and west sides of the watershed. Precipitation data have only been collected on the watershed since April 1994, but they have been collected in Tapalpa, Jalisco, since 1943. The 51 years of data from Tapalpa have been used here to characterized the annual and seasonal rainfall regimes on El Carrizal. Climate of this area is temperate. May is the warmest month of the year and normally signals the initiation of summer rains. Mean annual precipitation is 903 mm and ranges from 548 mm to 1,549 mm during the period of record (1943-1993). Seventy-nine percent of the annual precipitation (717 mm) is received during the period June through October. Summer monsoonal precipitation is proceeded by three months (February through April) which have an average rainfall of only 11 mm per month while rainfall during the months of November through January average 36 mm or less. It is important to know the distribution and timing of precipitation in order to determine the start of and critical growth periods for vegetation. Furthermore, one can also identify times to expect problems associated with soil erosion and flooding.

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Aquatic insects of the El Carrizal watershed and their relationship to water quality

Alvin L. Medina[1], J. Trinidad Saenz Reyes[2], y Constantino Orduna Trejo[3]

A collection of aquatic insects was made during the rainy season on various sites within the watershed. Insects were preserved and subsequently identified as to species. It is possible to predict the quality of aquatic habitat with respect to water quality parameters based on species information. The data show that potential water quality problems exist at specific sites that are associated with specific forest and range management activities. The preliminary assessment of aquatic insects is another tool that is used to determine the quality of riparian areas. Sites that have been degraded will have species of insects that are indicative of site conditions. This research will be complemented by other ongoing water quality studies of the watershed.

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Synecological characteristics of riparian vegetation of the Carrizal watershed, Tapalpa, Jalisco, Mexico

Yolanda Chávez Huerta[1], Alvin L. Medina[2], Xavier Madrigal Sanchez[3], and Trinidad Saénz Reyes[4]

Riparian vegetation is a vital component, despite it being very fragile, of an ecosystem that has great usefulness to man because of its potential for improving water quality. This type of vegetation reflects climatic changes and those induced by man within watersheds. For this reasons it is important to monitor its condition. The objectives of this study were to identify the principal riparian communities and to quantify the vertical structure and density. This study was carried out in the El Carrizal watershed, near the town of Tapalpa. Twenty-five stands were sampled using the methodology described by Medina (1986) for riparian areas, where presence, abundance, and cover of all species is quantified. Tree and shrubs attributes such as diameter, height and density were also determined. Total density, frequency, and constancy were calculated for each specie and subsequently used in principal component and cluster analysis, which permitted quantitative identification of the principal vegetation types or communities. Preliminary results revealed the presence of 8 major types or communities: *Alnus/Cornus excelsa/Salix oxylepis*, *Alnus/Cornus excelsa/Salix bondplandiana-Salix oxylepis*, *Prunus/Salix oxylepis/Rhamnus* spp., *Salix bondplandiana/Cornus excelsa/Salix oxlepis/Rhamnus* spp., *Ilex* spp., *Rhamnus* spp. /*Phoebe arsenii*, *Prunus brachybotrya/Rhamnus* spp., and *Alnus* spp./ *Prunus* spp./*Fraxinus* spp. Total tree density (60-100 trees/ha) and species diversity is high. Principal tree species include: *Alnus* spp., *Alnus firmifolia*, *Alnus arguta*, *Salix bondplandiana*, *Salix oxylepis*, *Fraxinus* spp., *Ilex* spp., *Phoebe arsenii*, *Prunus serotina* var. *serotina*, *Prunus brachybotrya*, *Rhamnus* spp., and *Cornus excelsa*. Principal shrubs included species of *Vaccinium*, *Senecio*, *and Rubus*. The presence of the genus *Carex*, *Juncus*, and *Cyperus* was of special interest because they serve to maintain streambank integrity, ameliorate the effects of floods, as well as other offsite effects related to management activities. The classification is proposed to be used to (1) better understand the structure and composition of the riparian vegetation, (2) establish a point of reference for other riparian studies where comparisons of types, species, etc, can be made, (3) provide basic, essential information for the development of watershed management plans, (4) provide a basis for defining critical wildlife habitats, and (5) provide a model for assessing the condition of the other watersheds in the region.

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Fire regimes and forest structure in the Sierra Madre Occidental, Durango, Mexico

Peter Z. Fulé and W. Wallace Covington[1]

Fire is a common and powerful disturbance in forested ecosystems of northern Mexico but little quantitative data on the frequency and ecological role of fire exists. In this study, four unharvested sites ranging from pine-oak to mixed conifer forest were sampled on ejidal lands in northwestern Durango. First comparing two paired unharvested pine-oak forest sites, we found that both had similar long-term regimes of fire disturbance, but the fire regime was disrupted at one site after 1945, leading to an extended period of near-total fire exclusion up to the present. Forest structures such as overstory and understory density, distributions of tree diameters and ages, and forest floor fuel loading were strongly correlated with this disruption in the fire regime: the fire-excluded site was dense with small trees and heavy rotten fuels while the frequent-fire site remained relatively open with fewer and larger trees and a lighter fuel load. Results from the third and fourth sites extended the range of variability in fire regimes and forest structures, including a high-elevation forest with Abies and Pseudotsuga. The forest and fire regime characteristics observed are consistent with the thinning and fuel-reducing effects of fire as well as the increased forest density observed in closely related fire-excluded forests elsewhere in western North America. Fire ecology data from Mexican forests may prove valuable both in guiding conservation and restoration efforts throughout fire-adapted North American forest ecosytems, as well as in calibrating models of changes in ecosystem structures and disturbance patterns under alternative scenarios of global change.

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Percent forest cover modeling of Mexico and Central America using time-series satellite imagery

Keith B. Lannom, Susan Eggen-McIntosh, Dennis M. Jacobs, and David L. Evans[1]

The United States Department of Agriculture (USDA) Forest Service, Southern Forest Experiment Station, Forest Inventory and Analysis (SO-FIA) is mapping the forest cover of Mexico and Central America by utilizing Advanced Very High Resolution Radiometer (AVHRR) 1 kilometer resolution data. Classifications of Landsat Thematic Mapper (TM) 30 meter resolution and System Probatoire d'Observation de la Terre (SPOT) 20 meter resolution data are being used to model the percent forest cover forest pixels of the AVHRR data. Aerial videography encoded with Global Positioning System (GPS) coordinates will aid in the classification of the satellite imagery. Geographic Information System (GIS) data from the Mexican Secretaría de Agricultura y Recursos Hidraulicos (SARH) are incorporated into the accuracy assessment of the TM classifications of Mexico. Ground verification work by Central America governmental and non-governmental agencies and historical aerial photography are the primary methods of assessing the remainder of the classifications. The results of this work will be maps of percent forest cover and forest type distributions throughout Mexico and Central America developed using a consistent methodology for the entire area.

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International volunteer exchange program between Mexico and the United States

Lawrence A. Mastic[1]

This program is an International Volunteer Program through the International Forestry Deputy area of the Forest Service. Based on the rapidly expanding environmental concerns that have occurred in both the United States and Mexico, there is a need to develop this program to take advantage of the opportunities that exist in both countries for forest ecosystem management. Potential cooperators in this effort, in addition to the USDA Forest Service and SFF-SARH (Secretaria de Agricultura y Recursos Hidraulicos) include the F.S. Research Stations, universities, private nurseries, and non-governmental organizations.

This proposal is modeled after but expands upon the current International Volunteer program that has been operating in the Southwestern Region since 1988. While the original program objectives would remain in place, there is a desire by both Mexican and U.S. forest scientists and managers, and the interested universities, to:

- Formalize some of the training opportunities;
- Design schedules and match participants to areas of more relevant experience; and
- Provide adequate funding to accomplish all objectives.

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Partnerships in natural resource management

Larry S. Allen[1]

The Coronado National Forest has many partnerships with neighboring landowners, federal and state agencies, and environmental groups. The National Forest shares a 65 mile border with the state of Sonora, Mexico and many of the partnerships include individuals agencies and non government organizations in Mexico. This poster will feature three cooperative planning efforts:

- Coronado National Forest/Sonora Sister Forest Agreement
- Lone Mountain San Rafael Valley Ecosystem Management Project
- Malpai Borderlands Planning Group

These three projects apply ecological principles and new technology to the planning of multiple resource management. All involve coordination with the private sector as well as numerous state and federal agencies in both countries.

As the only National Forest with a border with Mexico the Coronado has a unique opportunity for daily cooperation and interchange with the Mexican people.

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Ecosystem management: An experiment in managed stands

Andrew B. Carey, Suzanne M. Wilson, Todd M. Wilson, David R. Thysell, Lisa J. Villa[1], James M. Trappe, and Wes Colgan[2]

The Pacific Northwest is experiencing a crisis in ecosystem management illustrated by declining populations of northern spotted owls. Harvest of old-growth forests and shrinkage of habitat for old-growth dependent species underscore the need to incorporate development of old-growth attributes in management of young forests.

Our recent research shows that arboreal and forest-floor small mammals, the prey base of spotted owls, are generally more abundant in old-growth than in young managed forests. Our research also shows differences in the quantity and distribution of fallen trees, snags, and understory development account for much of the variability in small mammal populations across young and old stands. Additionally, spotted owl habitat use reflects mammalian prey abundance and degree of understory forest structural development.

In our current experiment, amplification of the mammalian prey base and creation of a mosaic of canopy densities are being tested in relationship to a sustained flow of wood and other forest commodities. We hypothesize that by influencing trophic pathways encompassing plant, fungal, invertebrate, and vertebrate populations, young managed stands may develop attributes more characteristic of old-growth forests.

Treatments in our experiment include creating cavities in live trees to benefit flying squirrels and other cavity-users and establishment of three levels of overstory density through silvicultural thinning to accelerate tree growth and stimulate understory diversity. Underplantings of additional tree species are expected to fill intermediate layers between tall shrubs and the forest canopy.

Our experimental design consists of four randomized blocks in second-growth Douglas-fir forest. Two blocks have substantial amounts of fallen trees and snags, and two blocks have virtually none. Each block has four 13-ha stands and four treatments: control, cavities-added, variable-density thinning with underplanting, and cavities plus variable-density thinning. Cavity and thinning treatments were applied in 1992-1993. Underplanting occurred in the spring of 1994. Our experiment links quantitative data to ecosystem components. Pretreatment and ongoing sampling includes vascular plant diversity and vertical structure, coarse woody debris, epigeous and hypogeous fungal diversity, abundance and diets of forest-floor small mammals, and detailed studies of arboreal rodents.

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Multiscale Analysis for the Lone Mountain/San Rafael Valley Ecosystem Management Area

Carrie Christman[1] and William J. Krausman[2]

Differing scales of spatial data provide different kinds of information about an ecosystem area. By using data ranging from very small scale to very large scale, important information can be represented regarding land use patterns and habitat distribution. This information is an essential tool for effective ecosystem management. This poster displayed varying scales of remotely sensed data encompassing the Lone Mountain/San Rafael Valley Ecosystem Management Area. Advanced Very High Resolution Radiometer (AVHRR) and Thematic Mapper (TM) satellite imagery, high altitude photography, resource photography, and on-site photography were used to show examples of different scales of data.

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Air resource management: An ecological approach

Frank Martinez[1]

The Clean Air Act (CAA) that was first authorized in 1963 requires air pollution prevention and control. The 1977 amendments promulgated visibility regulations for plumes generated by single sources or a small group of air pollution sources. The most recent 1990 amendments include new provisions that address regional haze and prescribed fire.

The Environmental Protection Agency (EPA) established national ambient air quality standards for six pollutants. The states or in some cases counties are authorized as the primary regulatory authorities for the CAA with some regulatory powers retained by EPA. Tribal governments may also apply for the same status as states.

The concept of Prevention of Significant Deterioration (PSD) was adapted to protect pristine areas. Three air quality classes were established, Class I, II, and III. The concept of Air Quality Related Values (AQRV) was established for Class I Areas. Mandatory Class I Areas include wilderness areas greater than 5,000 acres and national parks greater than 6,000 acres that were designated by August 1977, including subsequent additions.

The Forest Service Role: The key elements of the Air Resource Management Program apply to visibility and terrestrial and aquatic ecosystems. The major responsibilities are: monitoring; identify and protect Air Quality Related Values; Prevention of Significant Deterioration permit review; prevent or mitigate adverse impact due to forest activities such as prescribed burning; interagency coordination; disclosure of proposed project impacts to air quality; incorporate air quality issues in the Environmental Analysis process; research to support the program, such as obtaining accurate emission factors for fuels in a prescribed burn project; and education and awareness programs.

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Managing for sustainability on the Gila National Forest

Andrea Martinez and Maria Arrieta[1]

The Gila National Forest's commitment to ecosystem management and sustainability is demonstrated in the Luna Ranger District's watershed restoration projects, the 124,000 acre Negrito Ecosystem Project, as well as its entire fire and air quality program. The Gila is continuously seeking an ecological balance between the environmental resources with the present and future needs of the people.

For years, the Luna Ranger District has been the prototype for quality watershed restoration projects both for the Forest and Region. Severely degradated streams channels, meadows and riparian areas have been fully restored to sustainable and healthy ecosystems. For example, some meadows have been restored and once again serve as waterways for migratory birds.

A diverse group of people including commodity users, local ranchers, environmental groups, County Extension Agents, N.M. Game and Fish Department and Gila National Forest employees have been working cooperatively for the past three years in implementing ecosystem management on the Negrito Ecosystem Project. Desired future conditions for this area includes construction of watershed structures, silviculture treatments, wildlife improvements, and range improvement projects. On-the-ground resource projects demonstrate partnerships with various stakeholders and youth groups working together in ecosystem management.

Fire, mainly lightning-caused, have had a long history on the Gila National Forest. Today, fire management plays a leading role the Forest's sustainable ecosystem practices. Understanding wildfire behaviors, prescribe burning and fire suppression techniques is an intrigate part of ecosystem management in Southwestern New Mexico. The Gila has received both regional and national recognition for incorporating fire into its ecological approach to resource management.

Air quality is a priority of the Gila National Forest's ecosystem management program. Under the Clean Air Act (CAA), all wildernesses designated by Congress prior to 1977 is Class I and receives special protection under the Act. The Gila National Forest takes great pride in using the most modern equipment and scientific techniques in measuring and monitoring air quality (haze) on the Gila Wilderness. The equipment also measures fugitive dust and numerous other constituents that originate outside the Wilderness and Gila National Forest. Smoke generated from the Forest's prescribed burning is also measured and monitored.

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Woodworkers Alliance for Rainforest Protection: Conserving forests through responsible wood use

Dr. Richard Jagels[1] and Yurij Bihun[2]

The Woodworkers Alliance for Rainforest Protection (WARP) is a North American-based nonprofit association of wood producers and consumers focusing on responsible wood use and sustainable forest management. Formed in 1989, its members represent a broad cross section of individuals and organizations, including woodworkers, foresters, retailers, architects, policy makers, forest-product certifiers, environmentalists and consumers.

WARP's goals of sustainable forest management through responsible wood use are accomplished through: education, applied research, and fieldwork. Ongoing projects include:

- Shop Testing Program (STP) in which the working characteristics of lesser-known species are tested and evaluated;
- Development of a phone/fax/on-line service through which the conservation status of tropical hardwoods, and information on lesser-known wood species, certified wood sources, and surplus materials are disseminated to wood users and specifiers;
- Publication of Understory, the warp quarterly journal;
- Greenwood Furniture Project, a working alliance with Honduran artisans and forest managers to develop and manufacture a line of furniture using local facilities, labor and wood from certified well-managed forests; and
- Conservation by Design, a catalog and traveling exhibition of juried woodwork designed by an international selection of artists, sculptors, woodturners, and furniture makers who were challenged by WARP to explore practical, innovative solutions to the problems of forest conservation and responsible wood use.

WARP has also recently established a Fieldwork Fund which provides grants to applicant organizations and communities needing seed money to develop and promote valued-added forest products and non-timber resources from well-managed forests.

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The human dimension in sustainable ecosystem management: A management philosophy

David Harmer, Debby Potter, Rodney Replogle, Douglas Shaw[1], and Bev Driver[2]

Ecosystem Management as defined in the Southwestern Region is multiple-use management that integrates the needs of people with environmental values in such way that the National Forests and Grasslands represent diverse, productive and sustainable ecosystems. The human dimension must be integrated into ecosystem management to respond to human needs, because humans depend on natural ecosystems for their well-being and survival. Humans, like other living organisms, are integral parts of the ecosystem being managed. Humans influence and are influenced by ecosystems. Ecosystems affect peoples' physical, mental, spiritual, social, cultural, and economic well being.

The Forest Service's philosophy on ecosystem management recognizes that people are an inseparable part of ecosystems. Our philosophy also establishes ecosystem management as a human endeavor, seeking the well being of people and communities as well as the health of ecosystems. Most if not all of the critical issues pertaining to ecosystem sustainability are inherently human issues. Issues such as global change, endangered species, and forest health stem from human activity, are issues because of human concerns, and must be addressed through human ingenuity.

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Public information display to gain partners for sustainable forest ecosystem management in riparian ecosystems

Douglas W. Shaw[1] **and Rodney V. Replogle**[2]

Recently interest and understanding has increased in the scientific and management communities about the important role of riparian systems in sustainable ecosystem management. Frequently restoring and improving conditions in riparian areas means significant changes in land use, particularly for rural people who find these areas useful and desirable for many uses. People are more likely to join into partnerships if they understand the benefits of their changes and sacrifices to the common good.

Riparian values are discussed in terms of connections, changes, variety, and production. Riparian ecosystems connect other ecosystems from the high mountain streams to the oceans. Riparian ecosystems make changes in energy, nutrients, and minerals so they are more useful for life. Riparian areas are among the most active and changing portions of the landscape. Riparian areas are important to life because of their productivity, particularly for vegetation, the availability of water, and the frequent presence of minerals and other geologic materials.

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Ecosystem restoration and sustainability of the Mesa ecosystem management area.

Chuck Hagerdon and Roberto Martinez[1]

The French Mesa Ecosystem Management Area is located on the Coyote Ranger District, Santa Fe National Forest in northern New Mexico. The Ecosystem Management Area contains approximately 33,070 acres and is comprised of sagebrush and grass openings, piñon and juniper woodlands, extensive stands of ponderosa pine and occasional inclusions of mixed conifer.

The Coyote Ranger District encompasses several small predominantly hispanic villages. Spanish settlement of the area occurred during the late 1700's through the Spanish land grant system of partitioning lands. These communities are land-based, retain their traditional values and means of livelihood and are dependent on the natural resources of the area, including grazing and use of forest products.

During the past 80 years increased grazing of livestock and land use has had significant impacts in the French Mesa area. Sagebrush and other plant invaders have increased and erosion as evidenced by rapidly forming gullies has occurred. In the mid-1980's the Coyote District initiated a series of projects designed to improve past activities impacts by restoring wildlife habitat and the physical condition of the area. While these were separate projects initially, they were subsequently combined over the next several years into a holistic planning strategy for this area. Coordinating the planning and implementation of projects allowed the District to accomplish more work with greater efficiency and resulted in the designation of the Ecosystem Management Area (E.M.A.) with a focus on restoration and sustainability. The French Mesa E.M.A. has been scheduled for funding in fiscal year 1995 for an overall comprehensive plan, including: defining the area, describing existing and desired conditions and assessing all possible management practices to capture recent activities and consolidate the planning and implementation effort.

The success of this effort has been highly dependent on not only internal coordination and foresight at the District/Forest level but with coordination and technical assistance from other agencies such as the New Mexico Environmental Department, the New Mexico Game and Fish and the U.S. Environmental Protection Agency. A critical factor has been the direct involvement of the livestock permittees and the local community. The French Mesa project has received significant recognition including: The 1992 Southwest Region, USDA Forest Service Stewardship Award for conservation of soil, water and air resources; the 1993 U.S. Environmental Protection Agency Environmental Excellence Award for nonpoint source pollution management and control in watershed protection; and a USDA Unit Award for Superior Service for improved public involvement and using the team approach on the French Mesa Wildlife and Watershed Restoration Project.

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Effectiveness of grazing management in desert riparian areas

Richard Martin[1] and Lynette Mason[2]

Riparian areas are an extremely important ecological resource. They are especially valuable on the Tonto National Forest, much of which lies in the Sonoran Desert. The benefits of a healthy riparian ecosystem are numerous, including increased bank stabilization, improved water quality, elevated water tables, reduced flood peaks, increased forage production, improved wildlife and fisheries habitat, and enhanced recreation opportunities.

Many of the riparian areas on the Tonto have been degraded as a result of historic overgrazing. The forest is currently employing a number of different grazing management strategies in order to improve these degraded ecosystems. Practices being utilized include shortening the duration of grazing treatments, minimizing the frequency of grazing during the growing season, emphasizing winter/spring treatments, and utilization of riparian pastures.

Monitoring plays an important role in ensuring the recovery of riparian areas. Monitoring indicates the nature of changes occurring within riparian areas, and gives some insight into the rates at which any changes are taking place. This is an important feedback mechanism that allows us to determine the most effective grazing strategies. The Tonto utilizes photo points and quantitative surveys to monitor the effectiveness of each grazing system.

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Blacks Mountain interdisciplinary research project

William W. Oliver[1]

The development, restoration, and maintenance of old-growth forests are some of the most important issues currently confronting the Forest Service. It is not known if old-growth characteristics can be developed through the management of younger stands, nor is it known if we can manage old-growth stands to restore and perpetuate those characteristics through time. In addition, the relationships of forest productivity and biodiversity to the changes in forest ecological stages through time are largely unknown.

To answer these questions, a large-scale interdisciplinary research project is being conducted at Blacks Mountain Experimental Forest, in the eastside pine type of northeastern California. The objective of this study is to determine the responses and interactions of various ecosystem components (physical and biological) to the restoration of two distinct forest ecological states, as affected by various ground disturbances.

The structures being created are one of late seral stage (high structural diversity) and mid-seral stage (low structural diversity). The treatments will be replicated on twelve 100-ha plots. Additional treatments will alter the structure of the shrubs and the forest floor (amount of dead and down material, etc.) through the use of grazing and prescribed fire. These two distinctly contrasting forest structures will be developed and perpetuated to increase the probability of detecting:

- Carbon budget responses
- Changes in genetic and biological diversity
- Entomological relationships, especially bark beetles
- Factors of sustainability, including periodic fire
- Numbers and species diversity of small mammals, (including neotropical migrants) and herpetofauna
- Pathogen response
- Soil fertility processes
- Vegetation establishment and growth responses

Baseline data for vegetation, soils, wildlife, and insects has been collected. Fire history is being determined through tree ring analysis. Baseline genetic diversity is also being determined. Information is being integrated by referencing an accurate permanently monumented 100 meter grid. The data will be spatially and temporally analyzed using a Geographic Information System.

This project provides an opportunity for close cooperation with universities and researchers from other agencies/organizations, creating a research opportunity of unusual scope and significance. Currently, cooperating scientists from Michigan Technological University, Oregon State University, and the Intermountain Research Station are working on the project.

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Influence of site disturbance on fundamental productivity and soil processes in North American forests: "The LTSP experiment"

Robert F. Powers and William W. Oliver[1]

How do soil disturbances associated with timber harvest and vegetation control affect long-term site productivity? To determine this, a nation-wide experiment was begun by the U.S. Forest Service in 1989. To date, a network of more than 2 dozen common-protocol research plantations has been established on major forest and soil types across the U.S. and another 3 plantations have been installed in British Columbia in cooperation with B.C. scientists. The study is restricted to stands and soils likely to be managed for timber production under varying degrees of intensity (old-growth forests were not included). Core treatments involve nine factorial combinations of organic matter removal (bole only, whole tree, whole tree plus forest floor) and soil compaction (none, moderate, severe) that encompass the range of possibilities likely under management. Each 0.4 ha treatment plot is planted and "vegetation control/no vegetation control" is assigned as a secondary split-plot treatment. Other treatments aimed at mitigating disturbance effects have been included at some locations.

Preharvest forests are even-aged and near rotation age. The most severe treatments remove large amounts of organic matter, with the amount dependant on the nature of the harvested stand. This ranged from 97 t/ha (plantations in Louisiana) to 532 t/ha (natural stands in California). Changes in soil bulk density from the most severe compaction treatment depend on soil texture and initial density, and ranged from 9% (a fine silt) to 28% (a loamy clay). Soil strengths changed much more than bulk density. Generally, strengths were doubled or tripled following compaction and increased as the growing season progressed. Soil erosion rate was increased by the most severe treatment. Nitrogen mineralization was reduced both by compaction and by removal of the forest floor.

In the first few years after treatment, tree growth tends to be affected more by organic matter removal than by compaction, but differences depend on the site. Severe compaction combined with total organic matter removal reduced plant biomass production by more than one-fifth. Weed biomass is an important part of total potential productivity, and constituted more than two-thirds of the total dry matter production where vegetation was not controlled. However, weed biomass was so low on severely compacted plots that tree growth often was better than on uncompacted plots where vegetation was not controlled. On uncompacted plots, the presence of weeds reduced soil moisture availability by several weeks and shortened the potential growing season. Interaction between weed competition and soil compaction must be considered in assessing the results of more conventional experiments and in drawing conclusions for management.

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VOLUNTARY PAPERS

Applications of geographic information systems in assessments of El Carrizal watershed

Malchus B. Baker, Jr.[1], Yolanda Chávez Huerta[2], Alvin L. Medina[3], and Steve Dudley[4]

ABSTRACT.—A geographic information system (GIS) is being used to assess, monitor, and analyze land/water interactions on El Carrizal watershed in Jalisco, Mexico. Currently 18 major information layers, including cultural features, elevation, drainage system, geology, hydrography, land cover, land use, and soils reside in the GIS data base. In addition, precipitation, streamflow, and water quality data are stored in Paradox, a relational data base which is interfaced with the GIS. Examples of GIS implementations include potential erosion analysis, land use planning, and water quality modeling.

INTRODUCTION

The Riparian Area Restoration and Management (RARM) project was initiated in 1993 to assess, monitor, and analyze land/water interaction on El Carrizal watershed in the state of Jalisco, Mexico, near the town of Tapalpa (Medina, et al. 1995a). To meet these objectives, the capability to easily handle, store, and analyze large amounts of watershed data was necessary. Since the spatial attributes of these data, including hydrology, physiographic, geologic, soils, vegetation, land use, wildlife and cultural data, are important in understanding the functions and interactions occurring in the total watershed ecosystem, it was decided to use a GIS to help facilitate these tasks (Aronoff 1989). Hopefully, this project will ultimately provide us with the skills, software, and hardware to store and analyze data more efficiently and economically.

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STUDY AREA

El Carrizal watershed lies in the Sierra de Tapalpa mountain system which is part of the Volcanic Transversal Axis near Tapalpa, Jalisco (Figure 1). The forest is composed of temperate species of *Pinus* and *Quercus*. Climate is temperate with low humidity. May is the warmest month of the year and normally signals initiation of summer rains. Major rainfall (79% of the annual total) occurs during the period from June through October (Benavides-Solorio, et al. 1995). Mean annual precipitation is 901 mm (based on 51 years of precipitation data in Tapalpa, Jalisco).

Figure 1. Location of El Carrizal watershed near, Tapalpa, Jalisco.

El Carrizal watershed is 1,170 ha in area and ranges in elevation from 2,010 m at it's outlet in El Nogal Reservoir to 2,420 m at the top (Figure 2). The area above the 2,100 m contour is predominantly forested and comprises 71 percent of the basin (Figure 3). Soils developed in this area are classified using the FAO/UNESCO system (Buol, Hole, McCracken 1980) as eutric regosols developed on basalt parent material (Figures 4 and 5). A stream gauge is located at an elevation of 2,060 m and is used to measure stream-discharge derived from the forested portion of the watershed (Figure 6).

The lower portion of the basin, below the 2,100 m contour, is primarily nonforested land used for pasture or agriculture (Figures 2 and 3). Phaeozem

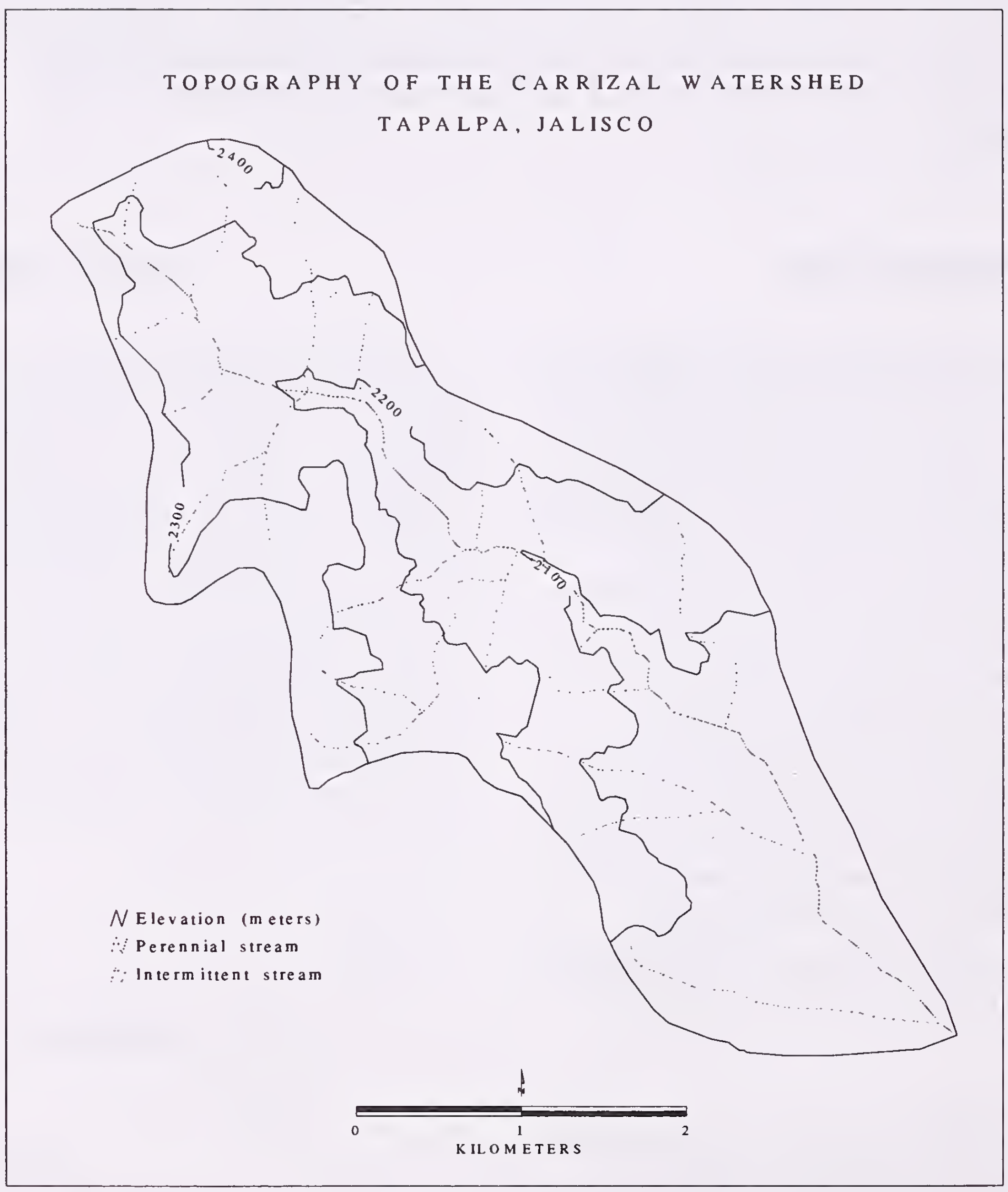

Figure 2. Topography map of El Carrizal watershed.

soils developed on alluvial deposits in this area are largely used for agriculture while phaeozem soils developed on basalt parent material are used as pasture for cattle and sheep (Figures 4 and 5). Tagle (1986) also reported the presence of humic Andosols, and chromic Cambisols and Luvisols.

The channel system, both perennial and intermittent reaches, is located on all watershed figures 2 to 6. The main channel is perennial for the whole length of the basin and extends primarily from northwest to the southeast.

Figure 7 shows existing ownership patterns on the watershed. The basin is divided into nine parcels with Pegueros having the largest share at 22% and Las Animas the smallest at 1% (Table 1). Table 1 also shows percentages of land use on each parcel.

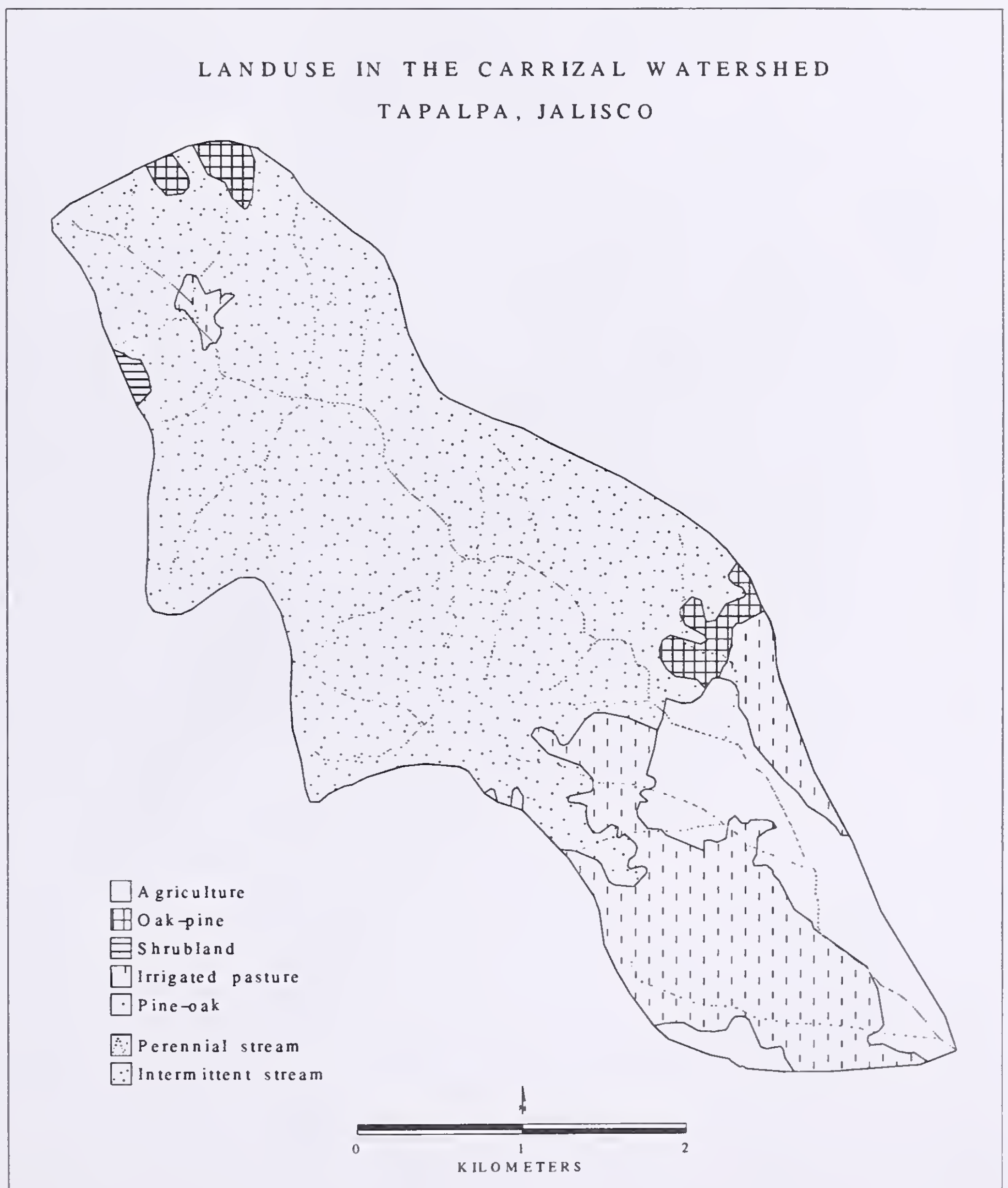

Figure 3. Map of land use and ownership boundaries on El Carrizal watershed.

Table 1. Ownership represented on El Carrizal watershed.

OWNERSHIP	PERCENT	LAND USE
AGUA ZARCA	16	FOREST
EL CASCO	4	25/75% FOR/PAS
EL DIVISADERO	3	FOREST
LAS ANIMAS	1	60/40% PAS/AGR
LAS MAQUINITAS	14	50/30/20% FOR/PAS/ARG
LOS ZAPALOTES	3	FOREST
PEGUEROS	22	FOREST
RANCHO CARRIZAL	20	60/40% PAS/AGR
SANTIAGO DE LA TORRES	17	80/20% FOR/PAS

METHODS

A raster data base structure is being used on this project with the capability of storing data in vector format. Data are input and analyzed using a number of software packages including the Earth Resources Data Analysis System (ERDAS), ILWIS, LTPlus, and PC ARC/INFO. Hardware used is PC-

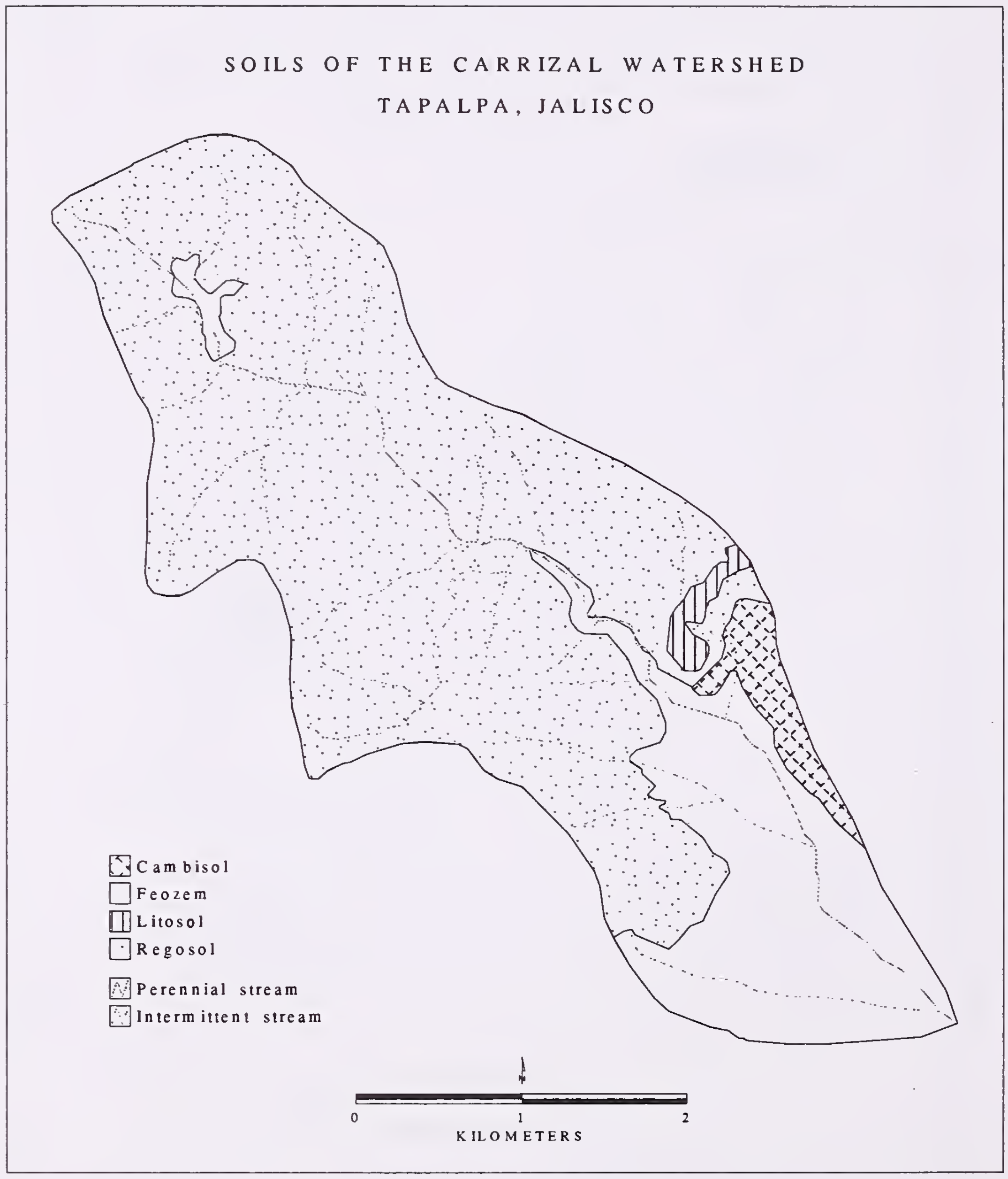

Figure 4. Map of soil types on El Carrizal watershed.

based. However, it is believed that some operation may be more efficiently performed in a workstation environment. If this is the case, we will use this information to determine tradeoffs between working on a PC versus a workstation.

The interfacing of Paradox and Informix, relational data base systems for PC and workstation, respectively, with the GIS is important because it allows data being collected daily or more often, such as hydrologic and water quality data, to be easily accessed and utilized by the GIS. Each record in the data base can be related to map coordinates using a station code of the sampling stations and therefore to any geograph-ically corrected image of the area.

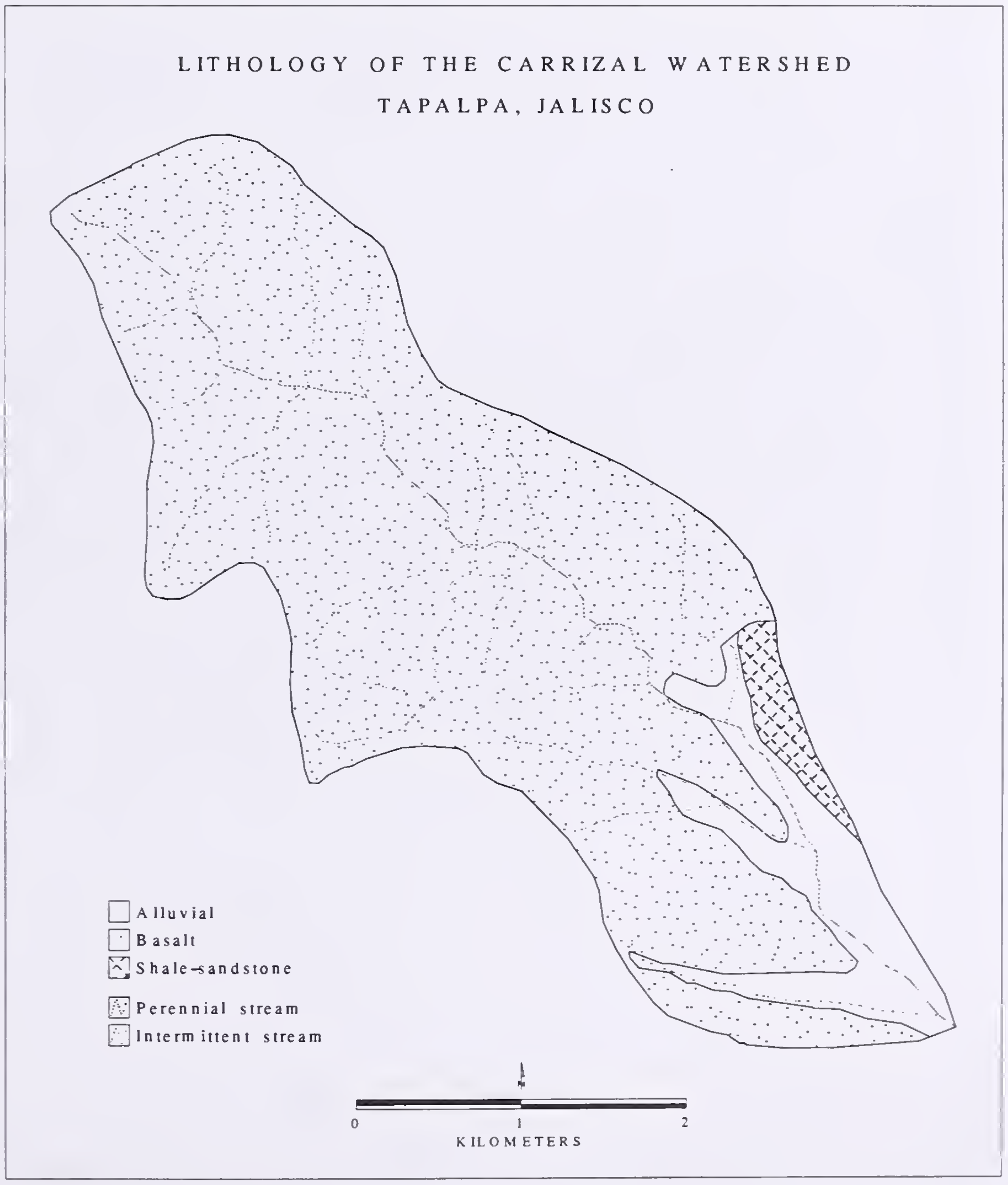

Figure 5. Lithology of El Carrizal watershed.

Data Sets and Coverage

The first step is to enter the data types into the relational data base systems. Water-quality, stream-discharge, and precipitation data are entered into Paradox. Basin and ownership boundaries, sampling sites, drainage system, geology, soils, vegetation, and land use were digitized from 1:50,000-scale topographic maps (INEGI 1976) and along with geographic attribute data entered into GIS.

Precipitation information is collected by four tipping-bucket rain gauges (Figure 6). The Theissen method is used to obtain average rainfall over the gaged watershed (Benavides-Solorio, et al. 1995). Streamflow is measured using a 120° V-notch weir and a pressure transducer to detect water depths

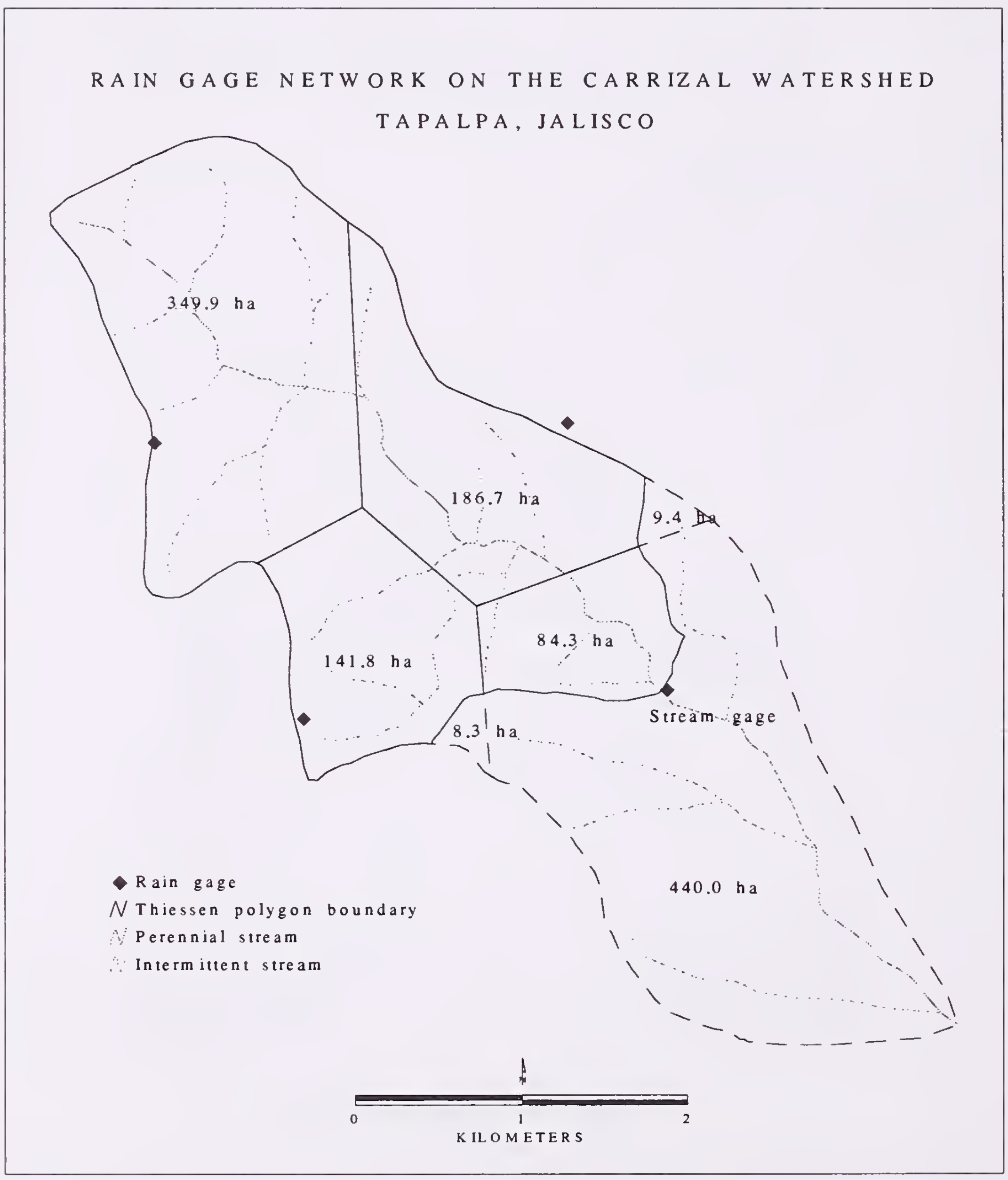

Figure 6. Locations of rain and stream gages on El Carrizal watershed.

which are stored in a micrologger (Baker, et al. 1995). The weir has a capacity of 2 m^3/s. Average water depths are stored for every 5 min period and converted to discharge. As previously mentioned the precipitation and streamflow data are accessed by GIS using an interface program to Paradox.

Water quality data are being obtained using automated water analyzer data logging devices (Medina, et al. 1995b). Water quality monitoring was initiated in April of 1994 at three location on the watershed. Information is collected every 30 minutes and includes water temperature, pH, specific conductivity, dissolved oxygen, dissolved oxygen/percent saturation, and total dissolved solids. Three automated water samplers are also used to obtain two water samples each day which

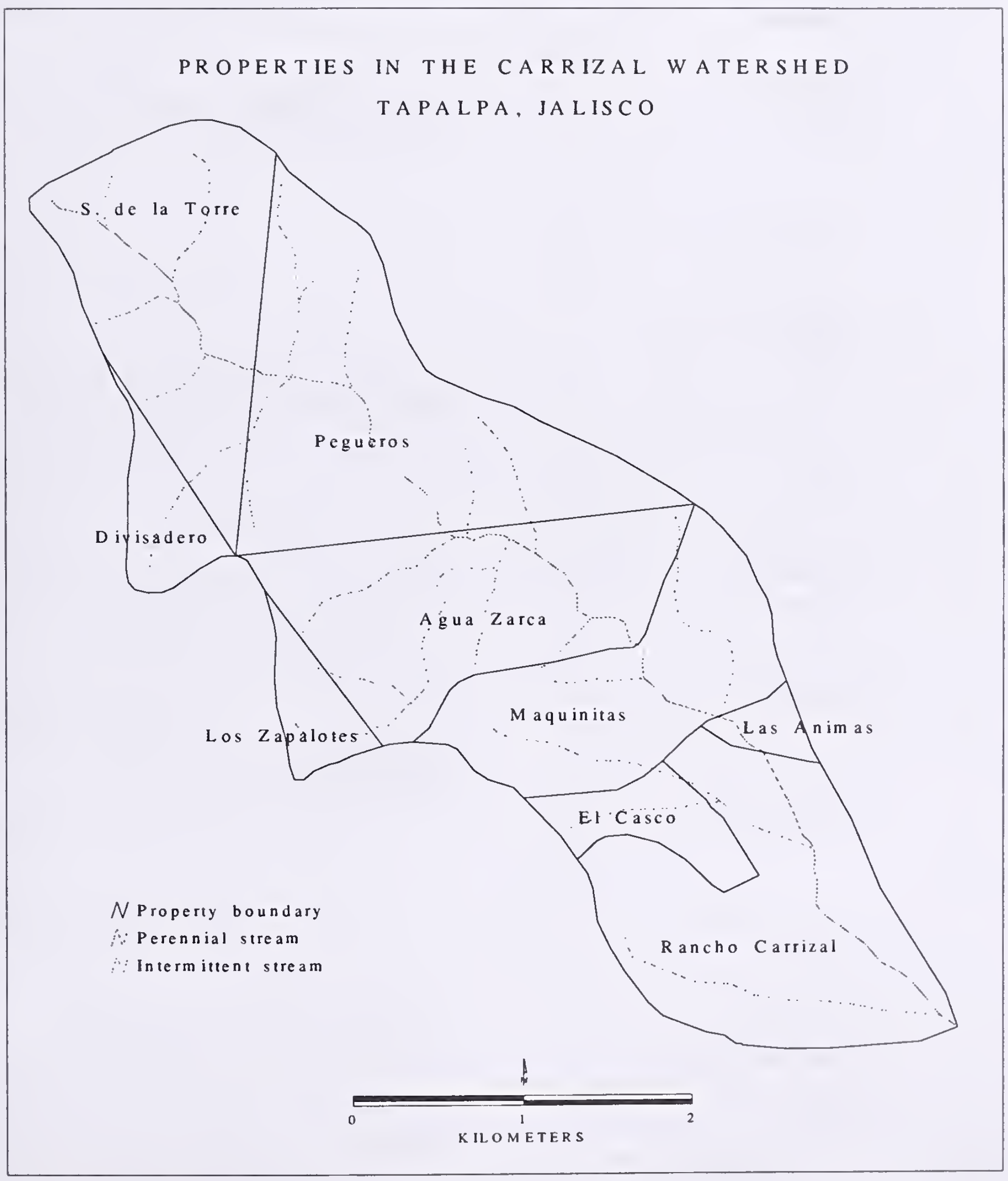

Figure 7. Ownership pattern on El Carrizal watershed.

Table 2.—Information layers and attribute files.

Information Layer	Attribute File
Cultural Features	
Ownership boundary	Ownership name
	Location
	Area
Roads	
	Station Code
	Location
	Kilometers
	Use
	Erosion Hazard
	Proximity to stream
Elevation	
Elevation	Contour value
	Location
Drainage Basin	
	Basin name
	Location
	Area
Geology	
	Parent Material
	Location
Channel System	
Perennial	Channel type
Intermittent	Location
	Length
Land Cover	
	Class description
	Location
Soils	
	Soil name
	Location
	Texture
Precipitation	
	Station code
	Location
	Theissen coefficient
Stream Discharge	
	Station code
	Location
Water Quality Data	
Hydrolabs	
	Station Code
	Location
	pH
	temperature
	Dissolved oxygen
	Conductivity
	Redox
	Total dissolved solids
ISCO (pumping sampler)	
	Station code
	Location
	Suspended sediment
	Nitrates
	Phosphorus
	Aluminum
	Iron
	potassium
	sodium
	sulfates
Dip Samples	
	Station Code
	Location
	Bacteriological
	Chemical
	Physical
Aquatic Macroinvertebrates	
	Station Code
	Location
	Species
Riparian Vegetation (Medina 1986)	
	Station Code
	Location
	Species (taxa)
	Species Composition
	Species Density
	Species cover
	Structure
	Classification of Habitat
Channel Classification (Rosgen 1994)	
	Station Code
	Location
	Width
	depth
	Substrates
	Slope
	Entrenchment
	Sinuosity
	Discharge
	Type
Wildlife Inventory	
Mammal	
	Station Code
	Location
	Species
	Habitat
	Associated species
Bird	
	Station Code
	Location
	Species
	Habitat
	Associated species

are analyzed to obtain additional water quality infor-mation on such parameters as, nitrates, phosphorus, sulfates, cations, heavy metals and suspended sediments. Dip samples are periodically collected at 6 locations on the watershed starting at the lake and proceeding up the basin. These samples are analyzed in a commercial laboratory for a set of bacteriological, chemical, and physical parameters. Sampling of macroinvertebrates (Plafkin et. al. 1986) is spatially coincident with the water quality sampling sites. Water quality data obtained are made available for GIS analysis through the relational data base interface.

Information Layers

The current data base consists of 18 major information layers. The various layers and associated attributes files are listed in Table 2.

GIS MANIPULATIONS

Analysis of information by a GIS can vary considerably. Information in any layer or attribute file can be retrieved on an individual basis and plotted on a map or output in statistical form. Any of the available fields in the data base may be accessed and displayed as text in different ways, or filtered so the data base can be selectively queried.

Although the display of information extracted from a single information layer and attribute file is often very useful, a better potential use of the GIS can often be realized when information contained in two or more information layers is manipulated. Figures 2 to 7 are examples of output products.

FUTURE ANALYSES

Although the immediate use of GIS has been to assist in the inventory and characterization of the resources on El Carrizal, some of the future uses envisioned for GIS include water quality analysis, both chemical and physical, to determine the presence of specific problems on the watershed and, if so, to what can they be attributed? Preliminary analysis indicate unusually high concentrations of iron, accumulations of fine sediments in the channel system, presence of aquatic macroinvertebrates species typical of contaminated conditions, elevated coliform, and diurnal fluctuations in pH at various locations on the watershed. Corre-lation of losses of any nutrient and sediments to their source of origin, particularly geologic parent material or soil type, and methods for reducing these losses need to be studied. The current road system is known to be a major source of fine sediments. Analyses of road conditions and their locations to the channel system, to various soil types, or to road design or construction should help identify remedial actions that can be used to reduce this source of sediments (Burns et al. 1995).

The physical appearance and character of a stream is a product of channel adjustments to its streamflow and sediment regimes (Rosgen 1994). Therefore the channel morphology data (Espinoza-Arechiga, et. al. 1995), coupled with vegetation (Chavez-Huerta, et. al. 1995), soil, water quality (Benavides, et al., 1995), flora (Sanchez et. al., 1995) and fauna data (Orduña-Trejo and Medina 1995a and 1995b) allows determination of overall health of the riparian system and provides vital insights into the condition of the entire watershed area.

Information on bird and mammal species are being collected for basic information on species diversity, abundance, and habitat condition (Trejo and Medina 1995a and 1995b). These data, along with other resource data, will provide a list of animal species present and information on habitat location and condition for the various fauna species found. Attempts will be made to identify species indicative of specific habitat conditions. The relative value of wildlife data coupled with other resource data is the ability to examine the watershed as a whole for potential causes of compartmentalization of species relative to management activities or existing patches of vegetation. These types of GIS analyses lend themselves to a variety of ways to examine cumulative effects on riparian and stream habitats (Hemstrom 1989).

These are just a few applications and analyses using GIS presently being considered. As we become more familiar with the watershed and more resource data are entered into the data base, many more applications will become apparent where GIS assistance can be effectively applied.

SUMMARY

The use of a GIS by the RARM project on El Carrizal watershed has allowed for the storage,

manipulation, and analysis of a large volume and variety of natural resource data. Preliminary use of these data has concentrated on inventory and characterization of watershed resources. However, many more uses of GIS are envisioned as more data become available and as GIS skill levels increase.

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Relationship between precipitation and streamflow on El Carrizal watershed, Tapalpa, Jalisco

Malchus B. Baker, Jr.[1], **Juan De Dios Benavides-Solorio**[2], **and Esteban Talavera-Zuñiga**[2]

ABSTRACT.—A 789 ha watershed was gaged to study the hydrology of the area and to assist in the assessment and restoration of its riparian ecosystem. Streamflow for the 1994 season began one month after the first summer precipitation occurred. Response in daily flow was generally associated with rainfall amounts of 10 mm or more. Maximum daily flow of 5.27 and 4.79 mm occurred following rainfalls of 60 and 35 mm, respectively. A total of 81 mm of runoff was produced from May through October by a total rainfall of 990 mm. Preliminary results indicate that stormflow is basically generated by subsurface flow and will average around 10 percent of the total annual precipitation (per year).

INTRODUCTION

A basic understanding of hydrology is fundamental in the planning and management of natural resources for sustainable use (Brooks et al. 1991). Knowledge of hydrology is needed to balance demands for water with supplies, to avoid floods, and to protect water quality.

Hydrology is implicit in the management of forest, range, and croplands. Ignoring the effects of land management activities on soil and water resources can lead to deterioration of both upland and downstream areas. Changes in vegetation and soil conditions can alter streamflow, sediment production, and water quality, and it can subsequently affect watershed condition and the health and welfare of people living in the area.

For favorable water flow, it is necessary to protect the physical integrity of the stream channel system and upland watershed while conducting land management activities. Basic hydrologic information is needed to understand the dynamics of a stream system (Rosgen 1994) and the physical instream flow processes needed for channel maintenance. This information will ultimately influence water quality (Medina, Benavides-Solorio, and Talavera-Zúñiga 1995b), wildlife (Orduña-Trejo and Medina 1995a; Orduña-Trejo and Medina 1995b), vegetation (Chávez-Huerta, Medina, Sánchez, and Reyes 1995; Sánchez, Medina, Reyes, Chávez -Huerta 1995), soil, and recreational needs in a watershed and is needed for the development of better guidelines for land managers.

The Riparian Area Restoration and Management (RARM) project was initiated in 1993 to assess, monitor, and analyze land/water interaction on El Carrizal watershed in the state of Jalisco, Mexico, near the town of Tapalpa (Medina et al. 1995). The primary objective of this paper is to report preliminary information concerning the precipitation regime on El Carrizal watershed and its influence on streamflow.

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STUDY AREA

El Carrizal watershed (Fig. 1) lies in the Sierra de Tapalpa mountain system which is part of the Volcanic Transversal Axis near Tapalpa, Jalisco. The forest is composed mainly of temperate species of *Pinus* and *Quercus*. Elevations on the watershed range from 2,060 m at the weir site to 2,420 m at the top of the basin (Baker et al 1995). Climate is temperate with low humidity. May is the warmest month of the year in Tapalpa and normally signals the initiation of summer rains. Major rainfall (79 percent of the annual total) occurs during June through October (Fig 2). Mean annual precipitation, based on 51 years of precipitation data in Tapalpa, Jalisco, is 901 mm (Benavides-Solorio, Baker, and Talavera-Zúñiga 1995).

The area above the 2,100 m contour is predominantly forested and comprises 71 percent of the total basin (Figure 3). Soils in this area are classified using the FAO/UNESCO system (Buol, Hole, McCracken 1980) as eutric regosols developed on basalt parent material. A stream gauge is located at an elevation of 2,060 m and is used to measure stream-discharge derived from the forested portion of the watershed. The basin area above the stream gauge is 789 ha.

Figure 1. Location of Carrizal watershed near, Tapalpa, Jalisco.

The lower portion of the watershed, below the 2,100 m contour, is primarily nonforested land used for pasture or agriculture (Figure 3).

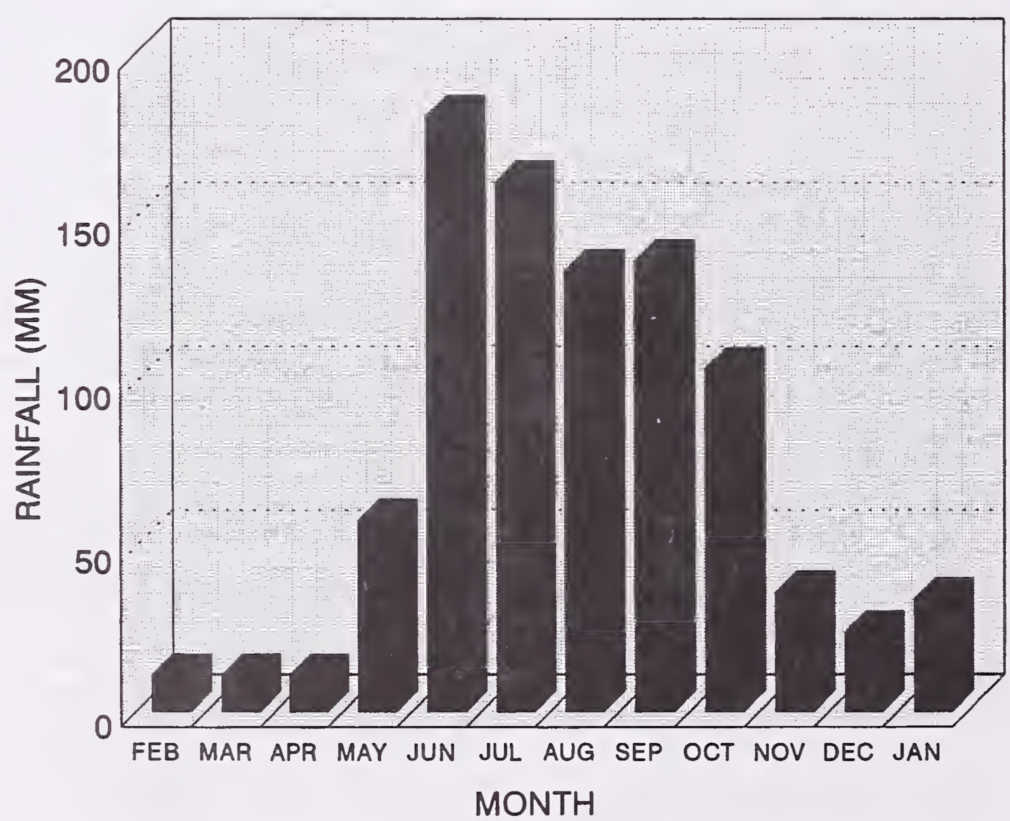

Figure 2. Monthly precipitation distribution at Tapalpa, Jalisco.

Figure 3. Map of land use on Carrizal watershed.

Phaeozem soils that developed on alluvial deposits in this area are largely used for agriculture while phaeozem soils that developed on basalt parent material are used as pasture for cattle and sheep. Soils on a small area in the lower portion of the basin are classified as chromic Cambisols.

METHODS

A one-meter, 120° V-notch weir (Fig. 4) was installed on the main channel of El Carrizal watershed during the winter of 1993-1994. This weir has the capacity to measure flows up to 2 m^3/s.

A micro-logger is used to store streamflow stage heights and rainfall amounts from a tipping-bucket rain gauge. Stage heights of water flow are converted to stream discharge and subsequently to area units of runoff. Area units of runoff are then compared to average area units of precipitation calculated from the weighed rainfall amounts of four rain gauges using the Thiessen method.

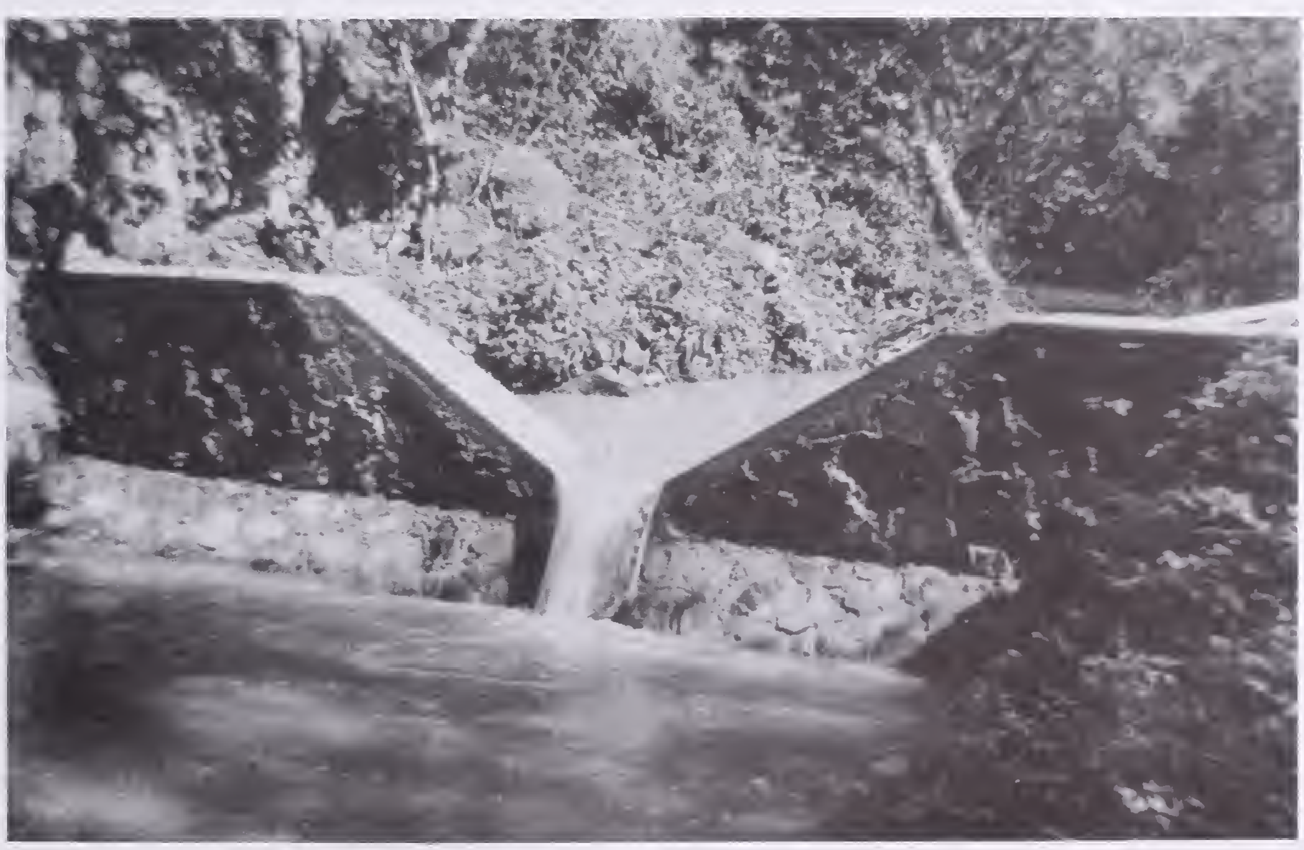

Figure 4. V-notch weir installed on Carrizal watershed.

RESULTS

Streamflow on El Carrizal watershed has only been gaged since the beginning of the 1994 rainfall period in May. Field observations indicate that flow is normally perennial above the diversion that supplies water to the ranch located below the weir. By May, streamflow probably reaches its annual low following the normal dry winter period (Fig. 2).

PRECIPITATION

From June through October in 1994, the period of most reliable rainfall on El Carrizal (Figure 2), daily rainfall (greater than or equal to 0.05 mm) occurred on 131 days out of a possible 153 days, or 86 percent of the time (Table 1). Rainfall occurrences ranged from 56 days for amounts of 5 mm or more, to 2 days for amounts of 40 mm or more. The three highest daily rainfall amounts were 61 mm, on 6 October; 40 mm, on 14 June, and 35 mm, on 14 October (Figure 5 and Table 3).

Rainfall statistics for 1994 (Table 2) indicate that the monthly rainfall distribution was similar to the 51-year average but the summer season total was 30 percent higher.

Table 1. Occurrence of daily precipitation on El Carrizal watershed, June to November 1994 (153 day period).

DAILY PPT (mm)	DAYS	PERCENT OF MAX
> than 0	131	86
> or = 5	56	37
> or = 10	32	21
> or = 20	14	9
> or = 30	7	5
> or = 40	2	1

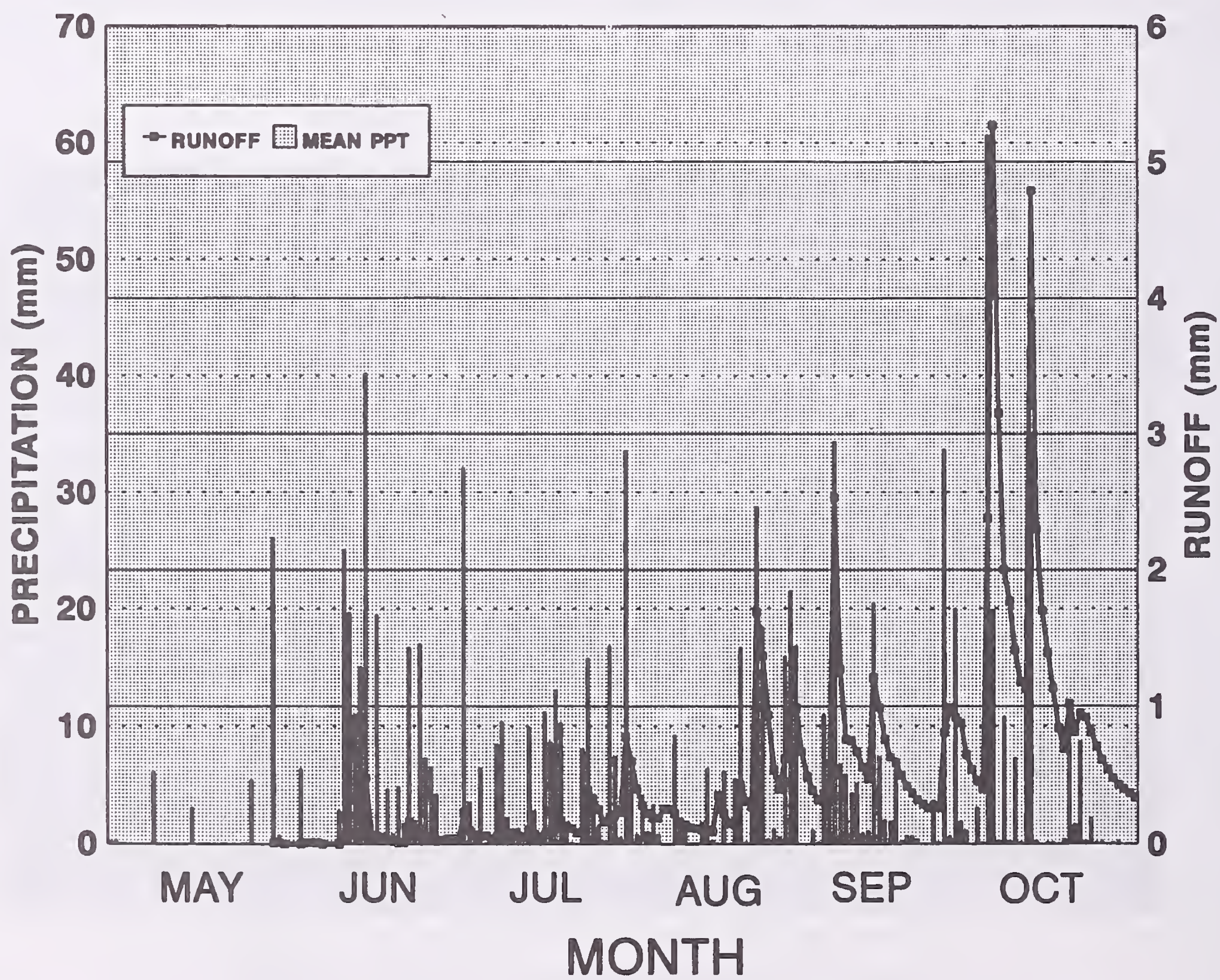

Figure 5. Daily precipitation and runoff on Carrizal watershed during the 1994 rainy season.

STREAMFLOW

Streamflow for the 1994 season was initiated one month after summer precipitation began (Figure 5 and Table 3). During that period, five storms had produced 15 mm of rainfall on the basin. Runoff was first measured at the weir after the storm on 28 May, which produced an average of 24 mm of rain.

Flow was intermittent for the next 2 weeks until another storm on 10 June yielded 27 mm of rain, and flow became continuous (Figure 5). Response in daily flow was generally associated with daily rainfall amounts of 10 mm or more.

The variable source area concept (VSAC) suggests two mechanisms that are responsible for stormflow response on a watershed: an expanding source (saturated) area that contributes flow directly to a channel, and a rapid subsurface flow response from upland to lowland areas that is principally the result of soil water displacement (Brooks et al. 1991). The stream channel and the riparian areas immediately adjacent to the channel system respond most quickly to a rainfall event. These wetter areas and shallow soil areas near the channel system can quickly become saturated as it rains and this saturated zone (hyporheic zone) expands both upstream and upslope as rain continues. Channels on El Carrizal and the associated saturated zone are relatively small at the beginning of the June rainy season following the normal dry season. Daily rainfall contributes water to the riparian zone and gradually is responsible for expansion of the saturated zone. During the first part of the rainy season, streamflow response was primarily associated with daily rainfall amounts of only 10 mm or more, but by late August changes in stormflow was much more responsive to smaller rainfall events and the general level in flow volume increased (Figure 5).

Additional water is stored in the basin soil upslope from the channel system and can also contribute to stormflow by the process of soil water displacement and by direct flow out of saturated zones near the channel system (Brooks et al. 1991). Midslope and low areas on a watershed can produce relatively quick responses in streamflow by displacement of upslope water into the saturated zone, while ridgetop areas may contribute little or no water to stormflow because much of the infiltrated water can be stored or the pathway is long enough to delay flow until long after a storm event.

The first major response in streamflow (0.61 mm) occurred on 14 June in association with 40 mm of precipitation (Figure 5 and Table 3), one of the two storm events that produced a daily total of 40 mm or more rain during the season (Table 1). The next major response in flow occurred on 1 August, reaching 0.78 mm of runoff in response to 34 mm of rainfall, one of 7 daily events that produced precipitation of 30 mm or more. Daily runoff first exceeded 1 mm (1.69 mm) on 25 August. Subsequent runoff then became more responsive to daily rainfall (Figure 5) because the saturated zone in the basin had significantly increased in size (Table 2).

Maximum daily flow volumes of 5.27 and 4.79 area mm occurred following rainfalls of 20 and 35 mm, respectively (Figure 5). Peak discharge of 5.27 mm on 7 October was obviously influenced by the 61 mm storm event that occurred on 6 October. The lag in response time provides evidence that streamflow is predominantly generated by subsur-

Table 2. Monthly rainfall statistics on El Carrizal watershed.

Month	Days of rainfall	---- Rainfall ---- 50-year mean	1994	Runoff	Runoff efficiency
		.... mm	....	....	%
MAY	9	58	40	0.02	0.0
JUNE	24	181	206	1.99	1.0
JULY	29	161	180	4.41	2.5
AUGUST	26	134	191	12.67	6.6
SEPTEMBER	26	137	193	20.16	10.4
OCTOBER	26	104	180	41.75	23.2
TOTAL		775	990	81.00	8.0

Table 3. Storm statistics for precipitation event (greater or equal to 20 mm) on El Carrizal watershed during period May through October 1994.

Date	PPT	Runoff	Antecedent precipitation 1-day	2-day	3-day
	....	....	area mm	....	....
5/28	24.34	0.01	0.00	0.00	0.00
6/10	27.48	0.08	2.99	2.99	2.99
6/14	39.87	0.61	15.60	23.60	40.54
7/02	31.38	0.29	0.34	0.92	1.19
8/01	33.52	0.78	.50	7.86	24.62

face flow. Although overland flow has been observed on the watershed, it is typically seen on roads and other limited areas of compacted or exposed soils where infiltration rates are easily exceeded by the rate of precipitation.

A total of 81 mm of runoff was produced during the summer of 1994 by a rainfall total of 990 mm (Table 2). This low runoff efficiency (runoff/precipitation of 8 percent), the relatively long period of time (hours) between rainfall and streamflow response, and the general lack of extensive overland flow occurrences indicate that stormflow is basically generated by subsurface flow and is likely to average less than 10 percent of the total annual precipitation.

CONCLUSIONS

- Preliminary streamflow results indicate the flow regime on El Carrizal watershed is primarily generated by subsurface flow.
- The saturated zone that contributes directly to stormflow on El Carrizal is relatively small at the beginning of the rainy season, following the normal dry season, and required nearly three months to reach a level where stormflow was noticable more responsive to daily rainfall even during an above average rainfall season.
- Generation of overland flow is largely restricted to roads and exposed soil areas where infiltration rates into the soil are easily exceeded by rates of precipitation.

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Low cost methods to control sedimentation from roads

Richard G. Burns, Lucas Madrigal Huendo and Daniel G. Neary [1]

Abstract.—Throughout the world there are many kilometers of gravel or natural surface roads located beside streams. With each rain, these roads put tons of sediment into the streams. Sediment reduces the water quality for human uses and aquatic ecosystem productivity. One objective of road management should be to protect adjacent resources, such as streams and riparian areas.

The obvious solution is to control the runoff that carries the sediment. Our runoff control method has three basic criteria: simple technology, simple design, and low cost. The central theme is simplicity. Since the practices are field designed, adjustments during construction are expected.

Construction should occur during dry weather since the work is located in areas where water and sediment already flow to the channel. If this is not possible, only start work that can be finished in the same day.

The practices presented can be built by hand or machines using resources that are readily available in the area. The seven practices are: (1) Wing ditches; (2) Sediment traps, (3) Berms, (4) Weeps, (5) Outslopes, (6) Humps, and (7) Relief pipes.

This method has been applied in a number of locations in the National Forests in North Carolina and appears to have reduced sedimentation in adjacent channels up to 75 percent.

THE PROBLEM

In all parts of the world there are many kilometers of gravel or natural surfaced roads located along streams. These roads put tons of sediment into the streams with each rain. Once in the channels, the water quality is reduced, often times to the point that it no longer meets human needs. Treatment costs to make this water potable are very high. The sediment may also make the water unsuitable for animal watering and irrigation, especially by spray systems. If the sediment loading is high enough, fish and other aquatic species may die and aquatic production reduced.

Sedimentation will also fill stream channels resulting in shallower water. Hence the channel capacity to carry high flows is reduced which can result in more frequent flooding of low lying areas adjacent the streams. Sedimentation causes problems in the irrigation canals and storage ponds by reducing their capacities.

Erosion of the road surface is also a problem. The loss of fine materials makes the surface rougher for vehicles traveling at high speeds. In

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some cases, erosion may make the road impassable. Often the only treatments considered are paving or graveling the surface or reconstructing the road in another location. These methods may reduce or prevent erosion and the flow of sediment to the streams. However, normally these methods are very expensive and often impossible to implement.

THE OBJECTIVE

One objective of road management should be to protect the adjacent resources, such as streams and rivers. These resources should be protected for human benefit. Sediment is expensive and difficult to remove from the stream channel once it is there. Aquatic system protection is easier and much cheaper when we control the runoff from the roads and prevent sediment from reaching the channel.

THE SOLUTION

The obvious solution to stopping chronic sedimentation is to control the runoff that carries sediment to the channels. Simply stated, the principal idea is to control the runoff so it does not flow directly to the stream channels. This is accomplished by redirecting runoff to sites where the water will infiltrate, or at least, deposit its sediment.

Three basic criteria were used in the development of our runoff control methods:

- *Simple technology.* The practices must be easy to construct and maintain. Only minimum training should be needed for people doing the design and planning of the project.
- *Simple but effective design.* The majority of the design should be made in the field. The method should not require detailed design effort in the office.
- *Low cost.* The practices should use resources that are locally available. The practices should be easily built by hand labor or with machinery such as bulldozers, motor graders and backhoes.

The practices used here are the same ones used to control erosion on construction sites and for other soil conservation. They include: new ditch outlets, sediment traps, berms, berm openings (weeps), humps, and relief culverts. With the exception of the humps, the practices are constructed outside or off the roadbed.

The basic idea is to disperse the runoff. That is, try to minimize the runoff volume and velocity any one point on the road. Therefore, you must use all available sites that can infiltrate runoff or trap sediment. It does not matter if these sites are small or large, you must use all of them. Also, notice that this idea is not the same as commonly used in other civil works where the runoff is concentrated into one spot for control.

THE DESIGN

The central theme is simplification. The majority of the design is done in the field rather than in the office. Detailed field notes are essential to ensure that the constructed practice will function as planned. Office planning should be limited to estimating the resources are needed: laborers, equipment and tools, hours to complete, gravel, seed, etc.

The first step in the project is to study the section of road selected for runoff control. This study or review of the area is necessary to get an idea of the existing conditions, the location of existing drainage and what practices might be needed. The second step is the actual field design. The critical sites are:

- where the runoff presently occurs;
- locations where the runoff reaches a channel now or will soon;
- locations where the runoff could be infiltrated;
- locations where the sediment could be trapped.

It is best to design from the lowest point on the road and plan up-grade. In this manner, it is easier to get an idea of the volume of runoff that will be collected at each point and to decide when a new

runoff outlet is needed. At each critical point, a practice or combination of practices is selected which will prevent the runoff from reaching a channel or at a minimum, trap the sediment in the runoff.

Each site is marked on the ground so it can be located during construction. The field notes should include details about what practice will be constructed at each site, its size, construction method, machinery and materials needed, etc. The important idea here is that the person who does the construction has enough clear information to achieve the desired results.

THE CONSTRUCTION

The construction plan for these runoff and erosion control projects is very important. Some of the work will be located in areas where road runoff is already flowing to a stream channel. The construction should occur when the chance of rain is minimal. If this is not possible, no more work should be started than can be completed in the same day. Also, you should consider the season and weather if the bare soils will be seeded and mulched after construction.

The design of these projects will probably need adjustment during construction since it was field designed. For example, a practice may have to be moved because of rock, thus changing the distance and runoff generated between two subsequent works. Therefore, you may need to adjust the size or location of the next practice. Another example would be if it was not possible to build a sediment trap as large as designed because the site is smaller than first thought.

THE PRACTICES

All the practices presented here can be constructed with hand labor or with light machinery. The design is the same; only the time needed to complete the work is different. It is important to construct the project using the resources that are readily available in the area.

Ditch Outlets: (Figure 1) Ditch outlets are additional wing ditches built along the road to reduce the volume of runoff in the ditch and to disperse it more frequently. With less runoff volume, the runoff can be infiltrated in a smaller area. For example smaller volumes could be infiltrated at several places in the narrow area between the road and the stream channel.

Notice that the goal is to have the water to pass through the outlet and not to deposit its sediment in the outlet. Therefore the bottom of the outlet should have enough slope so the runoff does not pond in the outlet. The ideal situation is for the new ditch bottom to continue to the point where it intersects with the natural ground line. The sides of the new outlet can be seeded, but the bottom should be left bare to prevent sediment deposition in the outlet. The only exception not to seeding the bottom is when excessive runoff velocity in a steep outlet could cause unacceptable erosion.

The new ditch outlets should be inspected frequently to ensure they function as designed and that sediment does not reach the stream channel. Normal maintenance is limited to cleaning the entrance and outlet of the ditch.

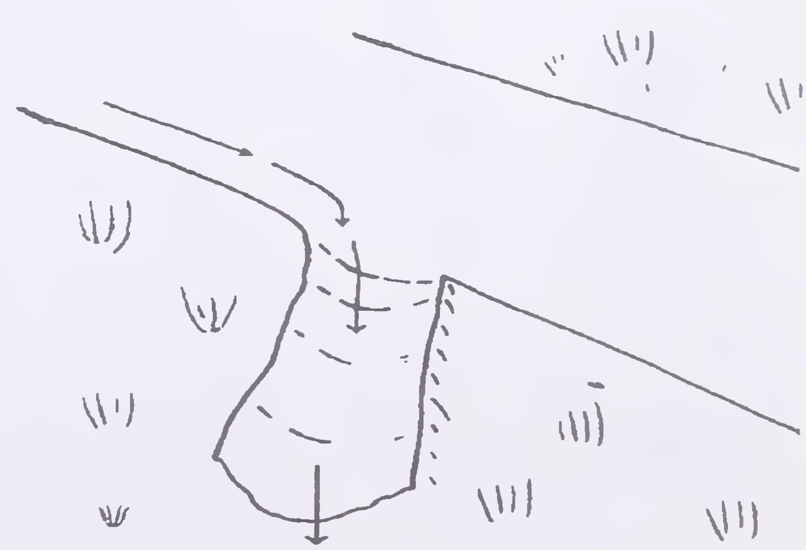

Figure 1.—Wing ditches.

Sediment Traps: (Figure 2) Sediment traps are holes excavated to trap and hold sediment that is carried in the runoff from the road. These holes are used where the concentrated runoff can not be infiltrated. Examples are the end of a ditch which is very near a stream channel or within a ditch that can not be outletted before it reaches a stream channel.

The size of the trap is limited by the space available and by the level of ground water. The volume of the trap should be large enough to reduce the velocity of the runoff below the point where sediment will be deposited. The larger the trap volume the less frequently it will need cleaning which reduces maintenance cost. The excavated soil can be spoiled anywhere it will not reach the stream channel. Sediment traps should be cleaned whenever they are about half filled so they will still reduce the runoff velocity adequately.

Berms: (Figure 3) Berms are mounds or dikes of soil at the road edge to keep the runoff on the road. They are used at sites where the runoff is flowing directly into the channel over a long distance rather than at a point. Berms are also used where there is no space between the road and channel to disperse the runoff or construct a trap. The goal is to keep the runoff on the road with the berm and direct it to an area where it can be infiltrated or a trap constructed. These constructed berms function the same as the berms that form "naturally" along roads.

The berms may be made of gravel or soil of the road or from new material brought to the site. The berm should be high enough to contain the anticipated depth of flow and no longer than necessary to reach an infiltration area. If the berm is long it may be necessary to use heavy (large) gravel to protect the road from erosion. Seed and mulch the soil berm immediately to prevent erosion and sedimentation of the adjacent stream channel.

The berm should be examined frequently to ensure that it is functioning as designed. It is very important to make sure that the berm is not destroyed during normal road maintenance.

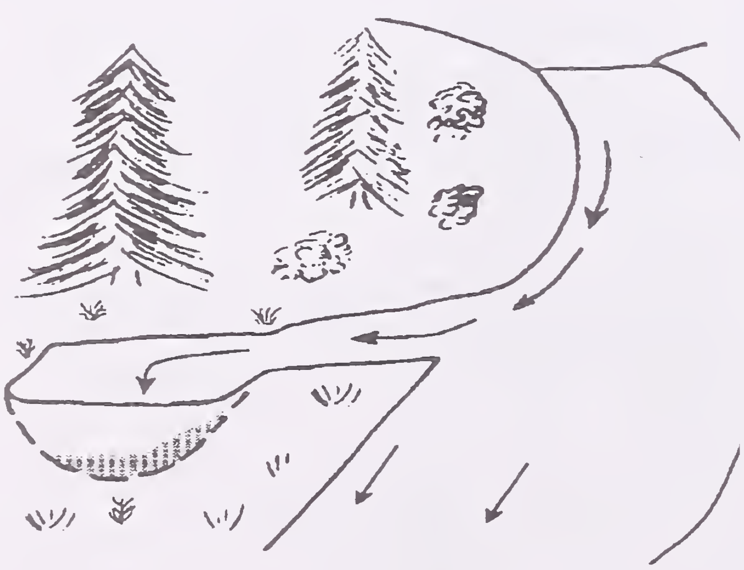

Figure 2.—Sediment Traps

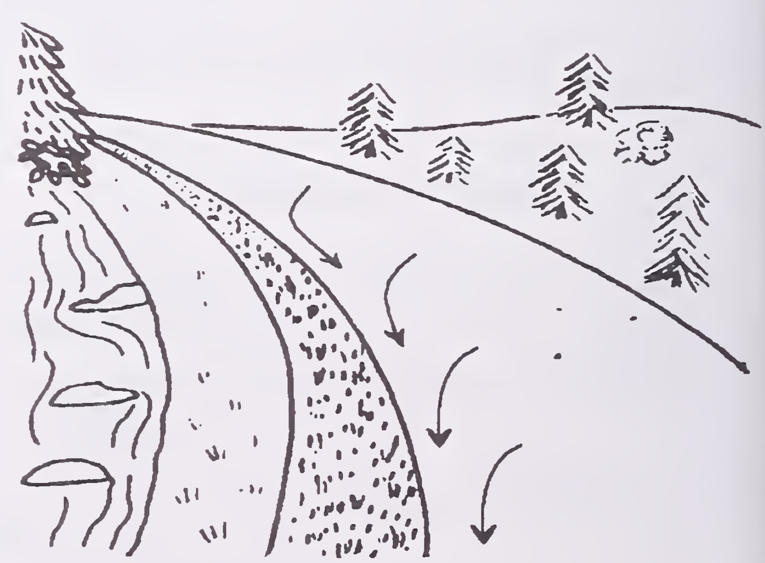

Figure 3.—Berms.

Berm openings (weeps): (Figure 4) Berm openings or weeps are "outlets" cut in existing natural berms to allow the runoff to leave the road surface and flow into the adjacent ground. These "natural" berms often form along a road as the result of traffic or maintenance and block drainage of road runoff. Openings are cut or made wherever there is an available infiltration area. Many times these openings are used with new outslopes built into the road.

Do not seed or mulch the new openings because it is important that the runoff pass through the berm and not deposit its sediment in the opening. The weeps or openings should be examined frequently to ensure that they function and are not blocked by a new natural berm.

Outslopes: (Figure 5) Outslopes are sections of road surface that are inclined toward the outside edge of the road so the surface runoff will leave the road surface. Roads that receive little maintenance or narrow roads where the vehicles travel in the center of the roadway commonly have flat or level (side to side) traffic surfaces. This condition allows the runoff to flow down the roads for long distances. Outslopes are used to shorten this distance by draining the runoff from the road. Outslopes are often used with berm openings.

Outslopes are best and most easily constructed using machines, however they can be made by hand but it takes much more time. The length of outslope section and its slope depend on the type and speed of the vehicles using the road. The outslope must be great enough to force the water off the road, but gentle enough that vehicles can pass over it without danger. The outslope section may extend over all or just part of the road width. Outslopes should be frequently examined to ensure that they have not disappeared and that a natural berm has not formed.

Figure 4.—Berm openings.

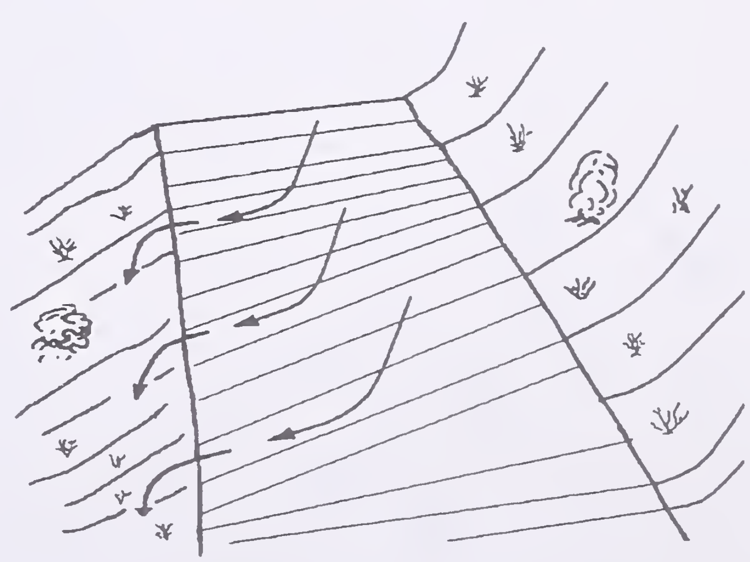

Figure 5.—Outslopes.

Humps: (Figure 6) Humps are sections of road surface that are built up to create a positive grade that causes the runoff to leave the road. Humps are used when the volume and velocity of runoff are causing erosion of the road surface. Normally, outslopes and openings are constructed just above (up grade) of the hump to ensure that the runoff leaves the road and its sediment is not deposited on the road.

Humps are made of new material brought to the site or from the road surface itself. The hump must be made of strong material. If it is not hard or strong, the hump will quickly be destroyed by vehicles during wet weather or by heavy vehicles. If soil is used to construct the hump, it is should be surfaced with heavy gravel.

Humps should not be abrupt like speed breakers. If possible, build the hump along the centerline far enough so the vehicles can pass over it without reducing their speed. Humps are constructed perpendicular to the road so that both front wheels of vehicle pass over the hump at the same time. If the hump is not perpendicular, the vehicle will twist which can result in mechanical damage. Humps should be examined frequently to ensure they have enough height to divert the runoff.

Relief culverts: (Figure 7) Relief culverts are new pipes installed to pass ditch water from one side of the road to the other so it can be infiltrated or its sediment trapped. Relief culverts are used to minimize the volume of water in a ditch that is flowing toward a channel. Also, they are used to reduce the amount of water in the ditch to a volume that can be infiltrated or sediment trapped in the small area available. Relief culverts are expensive and should be used only when no other combination of practices will accomplish the same objective.

Figure 6.—Humps.

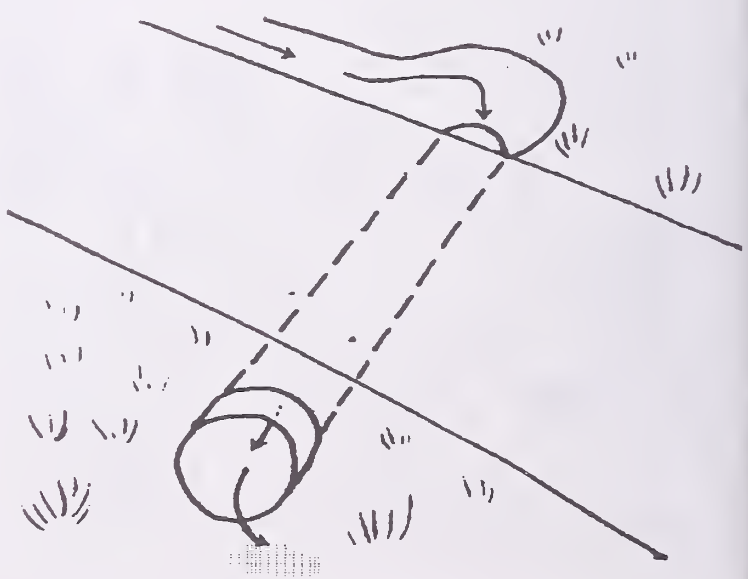

Figure 7.—Relief culverts.

SUMMARY

The objective of road runoff control projects is to stop sediment from reaching streams. Sediment in the streams reduces the water quality and increases treatment costs to make the water usable by humans. Sediment also reduces the productivity of the aquatic system, including the production of fish.

The practices used in the runoff control include: Sediment traps, Berms, Openings, Outslopes, Humps, and Relief culverts. The central theme of the process is simplicity. The three basic criteria used in the development of the methods are: simple technology, simple design, and low cost.

All the practices can be constructed by hand or with machinery using the resources available in the area. The practices are field designed with field notes detailing: the practice to be applied; its size, length, depth, height; materials needed; machinery and tools; etc. The designs of the works (such as size, position, etc.) are adjusted in the field during construction to ensure the practice functions as desired. The work should be planned when the probability of rain is low. At a minimum, start only work that can be finished in the same day if there is a risk of rain.

This method has been applied in several places in the National Forests in North Carolina. While we do not have scientific data, it appears that the method has reduced the level of stream sedimentation up to 75 per cent. Recently there was a heavy storm with up to 30 centimeters of rain in 24 hours. These practices helped reduce the damage to the roads and at the same time protected the streams.

A preliminary classification of the riparian vegetation of El Carrizal in Tapalpa, Jalisco, Mexico

Yolanda Chávez Huerta[1], Alvin L. Medina[2], Xavier Madrigal Sánchez[3], and Trinidad Saénz Reyes[4]

ABSTRACT.—The principal objective of this study was to identify a classification for the riparian vegetation of the 'El Carrizal' watershed in Tapalpa, Jalisco, México. The classification has many uses some of which are having a better idea of the major vegetation types of the riparian zone; to assist in the sampling design so that subsequent field sampling can be done within these major types, and thereby attain a better classification of vegetational units. Twenty-five transects were established, each was permanently referenced. Cluster analysis revealed the presence of 8 major groups: *Alnus/Cornus excelsa/Salix oxylepis, Alnus/Cornus excelsa/Salix bondplandiana-Salix oxylepis, Prunus/Salix oxylepis/Rhamnus* spp., *Salix bondplandiana/Cornus excelsa/Salix oxlepis/Rhamnus* spp., *Ilex* spp., *Rhamnus* spp. */Phoebe arsenii, Prunus brachybotrya/Rhamnus* spp., and *Alnus* spp.*/Prunus* spp.*/Fraxinus* spp. The classification is proposed to be used to (1) better understand the structure and composition of the riparian vegetation, (2) establish a point of reference for other riparian studies where comparisons of types, species, etc, can be made, (3) provide basic, essential information for the development of watershed management plans, (4) provide a basis for defining critical wildlife habitats, and (5) provide a model for assessing the condition of the other watersheds in the region.

INTRODUCTION

The structural composition of the vegetation of riparian ecosystems is of special interest to the resource manager because it can provide short and long term measures of the cumulative effects of natural factors (i.e. climate, geology) and man-induced changes through forest management practices (i.e. grazing, timber harvest, roads) (Brown et. al. 1978). Riparian ecosystems are recognized in the USA as being a natural resource of inestimable values (Johnson and Jones, 1977; Warner and Hendrix, 1984). The condition of these ecosystems has received wide attention (Johnson and McCormick, 1978) but there remains much to be learned about their structure and function, especially in terms of sustainability and ecosystem management.

The vegetation of riparian areas has been studied very little in Mexico. Solis-Garza et al. (1993) work in northern Mexico is the only study that examined the structure of riparian habitats and provided a classification thereof. In the Southwestern USA, there are several studies that classified riparian vegetation (Freeman and Dick-Peddie, 1970; Boles and Dick-Peddie, 1983; Medina, 1986; Szaro, 1989). The purpose of this study was to derive a preliminary classification of the riparian vegetation of the experimental watershed El Carrizal, using quantitative methods.

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Figure 1. The study area is located south of the city of Guadalajara, in the State of Jalisco.

STUDY AREA

El Carrizal is a small (1,284 ha) pine forested watershed located 6 km southwest of the town of Tapalpa, Jalisco, Mexico, in the Sierra de Tapalpa. Elevations range from about 2,010 m at the junction of the stream (El Carrizal) and a 18 million m^3 storage reservoir (El Nogal), and 2,420 meters at the highest point. The climate is temperate and subhumid Garcia (1981). Mean annual rainfall is 901 mm and ranges from 548 mm to 1,549 mm, with 79% of the annual precipitation (717 mm) occurring between June and October (Benavides-Solorio, 1995). Rainfall during the drought season (February - April) averages about 11 mm/month. The major soil units are (Gómez-Tagle-Rojas y Chávez-Huerta, 1986): humic Andosols, chromic Cambisols and Luvisols, eutric Regosols and Litosols.

The dominant vegetation is comprised of mixed stands of pine (*Pinus michoacana* Martínez, *P. oocarpa* Schiede, *P. leiophylla* Schl. et Cham., *P. douglasiana* Martínez and *P. pseudostrobus* Lindl.), with occasional stands of pine-oak (*Pinus*/*Quercus*) complexes (Benavides-Solorio, 1987). The better stands of pine are located from mid-slope to the ridge tops. The mid-story of stands in the middle slope zone is characterized by such species as *Crategus* and *Quercus*, which seem to extend over the watershed as a result of opening the site and timber harvest activities. The lower slopes are an assemblage of many woody species of trees, shrubs and vines. Some of the more common plants include species of *Arbutus*, *Alnus*, *Ilex*, *Persea*, and *Prunus* (Madrigal-Sánchez et al., 1995).

Historically and currently, the major activities within the watershed include livestock grazing and timber harvest. Apparently, livestock have grazed the watershed since the Tapalpa area was settled in mid 1600's. Archeological evidence of early settlements within the watershed to include exotic plants, pottery, rock houses, old sawmill and iron smelter sites. Rock is quarried and hauled out for use as road construction material and cobble for street pavements. Fire history is sparse but recollections are that at least two major fires have occurred since the turn of the century, the last being about forty years ago. Small fires (<1 ha) of undetermined origins occur occasionally and larger wildfires are guarded against. The greatest potential impact to the placid region may be the influx of people and associated development for tourism and resorts.

METHODS

Vegetation sampling of the riparian vegetation was conducted in spring and summer of 1994. A general reconnaissance of the potential vegetation types was conducted and study sites were randomly selected within each major type. A modified approach to canopy coverage method (Daubenmire, 1959) and adapted by Medina (1986) for sampling of riparian vegetation was used to establish an 8 x 40 m macroplot on opposite banks at each of 27 sample sites. Forty 0.625 m^2 quadrats (16 cm x 62.5 cm) were located along the centerline of the macroplot at 1 m intervals and cover was recorded for understory plants. The centerline was located on the streambank, 40 cm from the edge of the water or active channel. Aquatic species were recorded within the latter 25 cm of the quadrat which was extended into the water zone. Cover was also determined for exposed soil surface. Woody plants were recorded within 10 (4 x 5 m) macroplots about both sides of the centerline. All species were tallied as to species, height and DBH size classes. Nomenclature of vegetation follows Standley (1920), Rzedowski and Rzedowski (1979), and Rzedowski (1978). Community types names are denoted by listing codominant species within a

strata with a dash (-) and codominant species between strata with a slash (/), with the most dominant species listed first. Each macroplot was permanently referenced for subsequent examination. Plot data were summarized and density, frequency and constancy values determined for stands in an effort to standardize the data matrix (Romesburg, 1984). These parameters were summed to produce an importance value for use in an agglomerative hierarchical classification method (SAS, 1988) to identify groupings of stands. Euclidean distance was selected as the dissimilarity coefficient to use in conjunction with Ward's (1963) statistic. Facultative species were masked from analysis as the objective was to identify obligate riparian vegetation types (Stephenson and Cook, 1980).

PRELIMINARY RESULTS

All sites had species characteristic of mesophyllous montane forest types. There were 8 major vegetation groups identified by cluster analysis (Figure 2). The vertical axis is scaled in units of Euclidean distance. A subjective decision was made to designate groups at 3.5 units, since at this level the structural composition conformed to field observations. Vegetation types described herein are equivalent to plant associations.

The major associations are identified as follows:

- **Group 1:** *Alnus/Cornus excelsa/Salix oxylepis;*
- **Group 2:** *Alnus/Cornus excelsa/Salix bondplandiana-Salix oxylepis;*
- **Group 3:** *Prunus/Salix oxylepis/Rhamnus;*
- **Group 4:** *Salix bondplandiana/Cornus excelsa/Salix oxlepis/Rhamnus;*
- **Group 5:** *Ilex;*
- **Group 6:** *Rhamnus/Phoebe arsenii;*
- **Group 7:** *Prunus brachybotrya/Rhamnus;* and
- **Group 8:** *Alnus/Prunus/Fraxinus.*

The structure of the riparian vegetation is composed of several strata of dominant woody and herbaceous plants. In the tallest strata alder (*Alnus*)

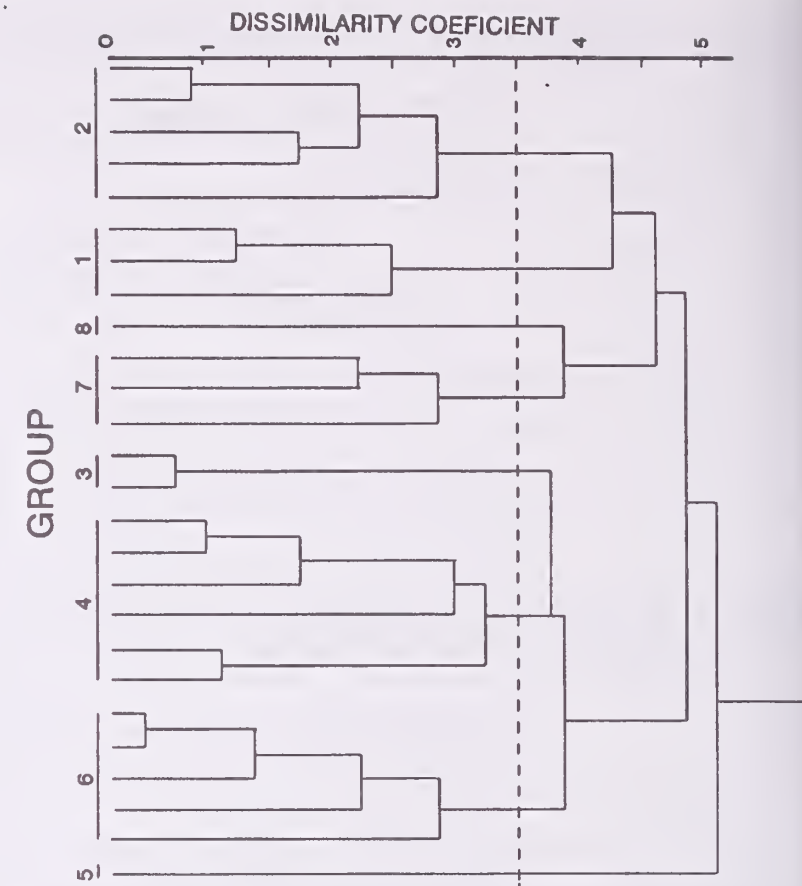

Figure 2. Dissimilarity coeficient dendrogram showing the relationships between vegetational groups. Linkage at coefficient = 3.5 was selected to illustrate the 8 major groups.

trees are the most prominent obligate species, with such facultative species as *Pinus michoacana* as a codominant. In the next strata, other species of alders, ash (*Fraxinus*), *Phoebe*, buckthorn (*Rhamnus*), *Salix bondplandiana*, and *Ilex* are dominants with some stands comprised mostly by *Phoebe* and *Ilex*. In the next shortest strata, *Cornus excelsa* and *Prunus* and some *Salix* species are most dominant. *Crategus pubescens*, commonly known as 'manzanita tejotera' (Standley 1920) is widespread in the latter strata and occupies the zone within the watershed about one-third the distance upslope, the riparian area, and deep upland swales where pine trees have been harvested. The plant is considered undesirable since foresters and land owners suspect that it shades out and competes for space, water and nutrients with desirable pine species.

Principal shrubs included species of *Vaccinium*, *Senecio*, *Salix*, and *Rubus*. Blueberries (*Rubus* spp.) cover much of the streambanks and in the upper and mid elevations of the watershed. Various species of vines cling and web themselves amongst the branches of shrubs and small trees. There are

also some toxic plants such as poison ivy (*Rhus radicans*), as well as other species of *Rhus*. Important herbaceous species such as *Carex* and *Juncus* were generally lacking owing to continuous yearlong grazing.

The relative density of obligate and facultative riparian trees and shrubs is presented in Figure 3. *Rhamnus* species comprise roughly between 10 to 20 percent and 25 to 50 percent of the tree density in groups 1 through 5 and 6, 7 and 8, respectively. *Crateagus mexicanus* was another species that was present in all groups with a relative density range between 15 to 30 percent. The other two major components were *Prunus* (includes *P. brachybotrya*) and *Cornus excelsa*. These 4 species groups dominate the mid-stratum or the small tree (4-10 m) class. Total tree density/ha ranges from 60 to 110 for the 8 major groups, with a mean of 75 trees/ha.

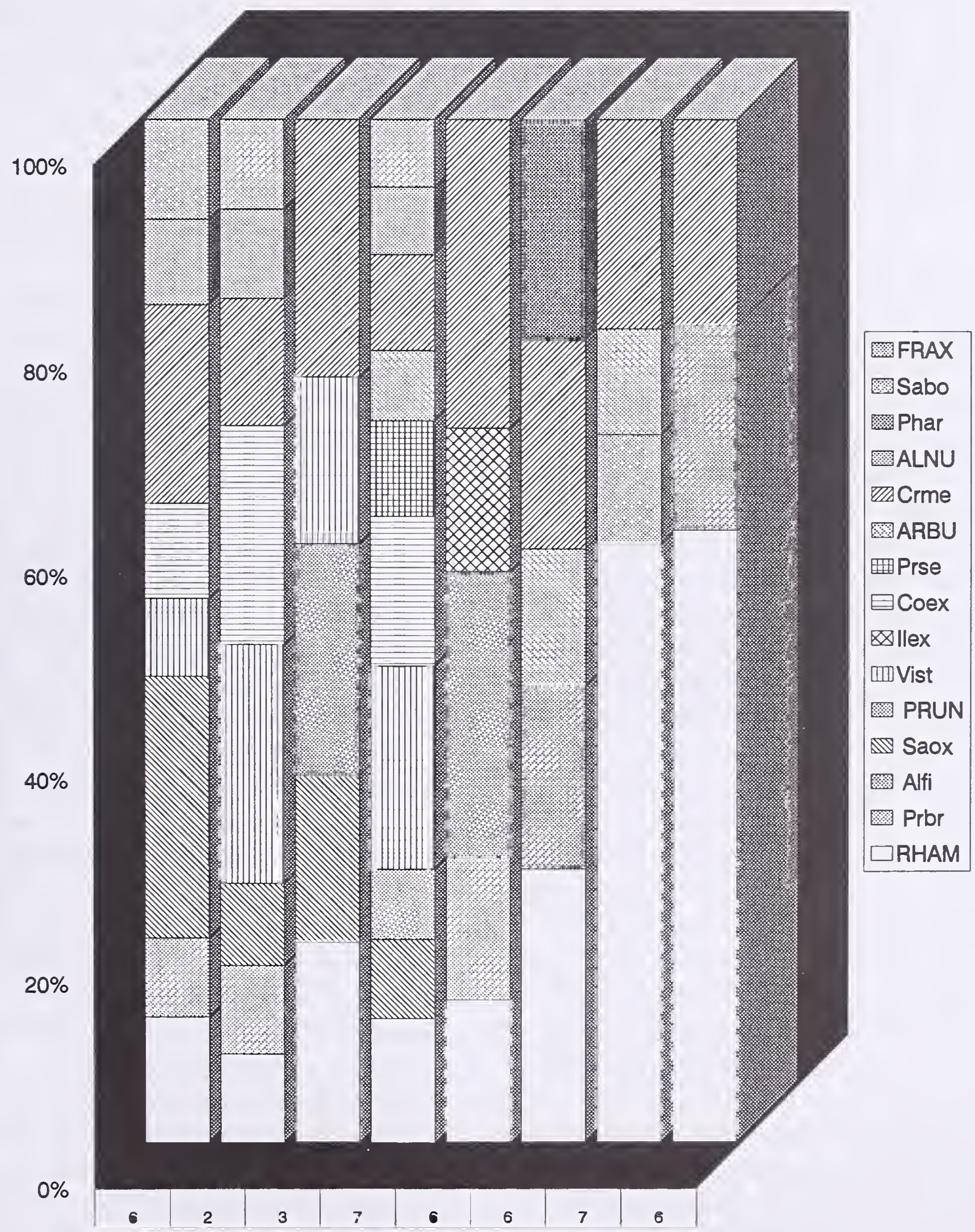

Figure 3. Relative density of the various species within each group. FRAX = *Fraxinus* sp., Sabo = *Salix bonplandiana*, Phar = *Phoebe arsenei*, ALNU = *Alnus* spp., Crme = *Crataegus pubescens*, ARBU = *Arbutus* spp., Prse = *Prunus serotina*, Coex = *Cornus excelsa*, Ilex = *Ilex* spp., Vist = *Viburnum stellatum*, PRUN = *Prunus* spp., Saox = *Salix oxylepis*, Alfi = *Alnus firmifolia*, Prbr = *Prunus brachybotrya*, RHAM = *Ramnus mucronata*.

DISCUSSION AND CONCLUSIONS

The results of this classification are preliminary, but serve as a basis for doing proportional sampling within each major group in order to attain a finer definition of association and community types. Initially, the general reconnaissance was used to accomplish the latter, but given the dense understory, one is apt to be biased towards the larger more readily observable plants. Considerable more work needs to be done to clearly identify all plants to the species level, which was not possible at this stage, since attaining an efficient sampling design was more pressing. Given this framework, sampling of vegetation will continue in 1995 until the entire riparian corridor has been assessed.

This classification can be used to examine and make comparisons between El Carrizal and other riparian areas of the region. In addition, it goes a long way towards developing a (1) better understanding of the structure and composition of the riparian vegetation, (2) establishes a point of reference for other riparian studies where comparisons of types, species, etc, can be made, (3) provides basic, essential information for the development of watershed management plans, (4) provides a basis for defining critical wildlife habitats, and (5) provides a data base that can be singly or collectively used with other relational data bases (Baker et. al., 1995) to make better assessments of watershed condition.

The definition of obligate and facultative species is important in order to relate the degree of disturbance or departure from the potential natural vegetation of the riparian ecosystem. Determining the 'degree of disturbance' permits the relative assessment of one watershed to another with respect to forest management activities, such as grazing and timber harvesting. The more a riparian plant community departs from natural conditions, the more it is apt to be in a deteriorated condition. For example, the species composition may reflect a high degree of diversity but the bulk of the species are of the ruderal type or may include a large quantity of introduced species. Additionally, important aquatic obligate species of the genera *Carex* or *Juncus* may be entirely absent, thereby possibly reflecting a disturbed condition exemplified by poor bank stability, channel downcutting and dewatering of the riparian zone, and possibly a grazing disclimax.

The work provided here is but a starting point for classifying the riparian vegetation of many regions in Mexico. The classification and interpretation thereof are the next steps towards understanding and diagnosing dysfunctional ecosystems, especially when coupled with the identification and classification of channel types (Rosgen 1994). Understanding these classifications are essential for understanding the structure and function of riparian ecosystems, and hence their value to man.

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Habitat and breeding ecology of amphibians of the tropical deciduous forest of Jalisco, Mexico

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ABSTRACT.—Tropical dry forests constitute some of the most threatened of the major tropical forest ecosystems. Anurans are among the many species of organisms that have evolved to take advantage of the extreme seasonal variation of the dry tropics. For example, anurans are able to vary their timing of reproduction, and some have developed special adaptations that allow them to breed in xeric conditions. Because different species have different breeding requirements, they can be expected to show a range of responses to land use practices such as timber harvesting, grazing, or recreation. In this paper, we briefly review the life histories of selected anurans inhabiting the dry forests and lowlands of the state of Jalisco, western Mexico, where 19 species are known to occur. We view the transferral of information on breeding requirements of tropical anurans to resource managers as a key step in developing effective guidelines for their conservation. We also discuss their conservation in relation to factors that limit their habitat use and breeding opportunities.

INTRODUCTION

Populations of many anuran species are declining globally (Anonymous Science Briefing 1991). Their declines may signal both widespread environmental problems and/or the destruction of critical habitats. Although numerous anuran species are known to inhabit tropical forests, the life histories, demographics, and population status of many have not been described. Without more comprehensive information on the basic habitat requirements of tropical anurans, governmental plans to conserve tropical biological diversity will most likely fail to include anurans.

Tropical dry forests are some of the most threatened of the major tropical forest types, largely because these forests can be cleared for pastures and fields and readily maintained by fire owing to the severe dry season. In this paper, we describe adaptations of anurans inhabiting tropical dry forests, focusing on the natural histories and habitat use of selected species sampled in Jalisco, Mexico. Our intent is to focus attention on anurans as a legitimate taxonomic group to include in plans for sustaining the biological diversity and integrity of native tropical dry forests. Anurans may be useful indicators of perturbations if their biological responses and population changes reflect changes in overall ecological systems.

HABITAT USE AND BREEDING BIOLOGY OF ANURANS

Anurans are among the many species of organisms that have evolved to take advantage of the extreme seasonal variation of the dry tropics. There are approximately 19 species of anurans known to occur in the lowlands of western Mexico

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in the state of Jalisco (Casas-Andreu, 1982; Table 1). While some of these species can occur in other habitats, many are dependent on dry tropical forest to meet their habitat and reproductive needs. Adaptations to seasonality include opportunistic breeding when there is sufficient rainfall, and development of foam nests as a defense against xeric conditions.

Studies of breeding behavior in frogs suggest that they exercise considerable choice in the selection of breeding sites, and may change their breeding site requirements throughout the rainy season (Howard, 1978; Aichinger, 1987; Crump, 1991; Ford, 1992; Ford and Scott, 1994). Resource managers need to be cognizant of the role of rainfall, drought, and climate change in determining habitat occupancy, population viability, breeding site selection, and timing of reproduction of anuran species.

The dry tropics of western Mexico contain at least six species of early breeding anurans (Ford, 1992; Ford and Scott, 1994). These species are generally opportunistic breeders that coordinate their reproductive activity with patterns of rainfall. Other species require steady rainfall or a large amount of rainfall to stimulate them to breed. Species that are opportunistic breeders generally have shorter larval development time than do species that breed later in the rainy season. In ephemeral pools formed by short-term or sporadic rainfall, larval development of opportunistic breeders must occur before the pools dry out. Species that breed later in the rainy season use larger or more permanent water sources, therefore reducing the threat of dessication. Foam nests may also be created to protect eggs from dessication until there is sufficient rainfall to allow the tadpoles to complete their development, as in the case for *Leptodactylus melanonotus*.

Even early breeding species have differing habitat requirements. Species differentially use forested areas, nonforested areas, or both to breed. Species that can breed in both forested and nonforested areas are generally more abundant than those restricted to forested or nonforested areas. For example, in a study of the breeding requirements of amphibians in Jalisco, Ford and Scott (1994) found that *Gastrophryne usta*, a species that breeds primarily in forested areas, was relatively rare while *Smilisca baudini*, a species that can breed in both forested and nonforested areas, was relatively common.

BREEDING HABITATS OF SELECTED ANURAN SPECIES

Representative species from five families of anurans inhabit the dry tropical deciduous forest of Jalisco (Table 1). The family Hylidae, the Treefrog family, has eight species known to occur in this area. Some examples include *Smilisca baudini* and *Pternohyla fodiens*. *Smilisca baudini*, the Mexican Treefrog, is an opportunistic breeder, laying eggs when sufficient rainfall creates temporary pools.

Table 1. Amphibian species known to occur in the tropical deciduous forest of Jalisco, Mexico (from Casas-Andreu, 1982, Ford, 1992).

Family Bufonidae
- *Bufo marinus*
- *Bufo marmoreus*
- *Bufo mazatlanensis*

Family Leptodactylidae
- *Eleutherodactylus hobartsmithi*
- *Hylactophryne mexicanus*
- *Leptodactylus melanonotus*
- *Syrrophus modestus*
- *Tomodactylus nitidus*

Family Hylidae
- *Hyla sartori*
- *Hyla smaragdina*
- *Hyla smithi*
- *Agalychnis dacnicolor*
- *Phrynohyas venulosa*
- *Pternohyla fodiens*
- *Smilisca baudini*
- *Triprion spatulatus*

Family Microhylidae
- *Gastrophryne usta*
- *Hypopachus variolosus*

Family Ranidae
- *Rana berlandieri*

The temporary pools range in size from shallow, muddy puddles to extensive ditches or large flooded areas. It deposits its eggs in a surface film on the water (Duellman and Trueb, 1966). It is found in humid places along streams, in canyons, in trees and in shrubs where it hides under loose bark, in tree holes, or in damp earth (Behler and

King, 1979). *Pternohyla fodiens*, the Burrowing Treefrog, times onset of breeding with the summer rains from July to August. It is adapted to living in burrows where humidity is high. The Burrowing Treefrog is thought to use its bony skull to plug its burrow against predators and to slow the loss of moisture (Behler and King, 1979).

The family Leptodactylidae, the Leptodactylid frog family, is represented by five species in the Jalisco tropical dry forest. Leptodsactylids are a diverse group exhibiting a variety of reproductive strategies in dry environments. Some examples include the species *Eleutherodactylus hobartsmithi* and *Leptodactylus melanonotus*. *L. melanonotus* lays its numerous eggs in foam nests in the water. In the more xeric portions of its range it is found only in association with permanent bodies of water such as persistent springs (Heyer, 1970). On hatching the tadpoles escape into the water where they live until metamorphosing into frogs. In contrast, *E. hobartsmithi* lays fewer than two dozen eggs in moist leaf litter or damp earth. The eggs hatch two to three weeks later, releasing fully developed miniature frogs (Behler and King, 1979). Both of these strategies, though very different, allow each species to exist in an area with a pronounced dry season.

The family Bufonidae, the Toad family, is represented by three species. All three species breed opportunistically with adequate rainfall using temporary or permanent streams and ponds. They are primarily terrestrial and found in humid sites with adequate hiding places. *Bufo marinus* and *Bufo mazatlanensis* lay their eggs in strands in water, while *Bufo marmoreus* lays single adhesive eggs (Blair, 1972). *B. marinus* is tolerant of disturbed areas and possesses adaptations that enhance its survival. In particular, it secretes a highly toxic substance from its parotoid glands that can cause death in animals and will irritate the eyes and skin of humans.

The family Ranidae, the True Frog Family, is only represented by one species, *Rana berlandieri*, the Rio Grande Leopard Frog. Primarily amphibious, it lives along the edge of water and can breed year-round. Egg masses are attached to submerged vegetation (Behler and King, 1979).

The family Microhylidae, the Narrow-Mouthed Frog Family, is represented by two species, *Gastrophryne usta* and *Hypopachus variolosus*. They live in moist places including along the margins of ponds, marshes, under leaf litter, or in subterranean burrows, and breed with sufficient rainfall. Eggs are laid as a surface film by *Gastrophryne usta*, the Narrow-Mouthed frog, and as floating rafts that hatch within 24 hours by *Hypopachus variolosus*, the Sheep Frog.

CONCLUSIONS

Knowledge of anuran breeding patterns and requirements are critical for developing effective guidelines for amphibian conservation. For example, managers should know the following about the species and populations they wish to conserve:

1. Breed early, late, or year-round,
2. Use temporary ponds, permanent water bodies, running water, or non-aquatic sites (e.g., leaf litter, burrows),
3. Opportunistically breed in response to rainfall or are independent of rainfall,
4. Are flexible or specialized in choice of breeding sites and habitat types,
5. Are rare, common, or abundant, and
6. Can tolerate disturbance, including water and air pollution, and presence of humans or introduced species.

Steps for conserving amphibians include:

- Identifying or inventorying the species that inhabit the geographical area of interest;
- Accounting for species differences in timing of breeding and habitat selection;
- Developing a data base describing habitat requirements and limitations to breeding;
- Identifying how habitat changes in the area may inhibit breeding opportunities and threaten survival of adults, eggs, and larvae, thereby jeopardizing population viability; and
- Forcasting or monitoring population responses to different management actions.

Examples of factors that can potentially damage habitats or productivity of anuran species include:

1. Pollutants such as factory chemical outputs, sewage, and human waste that are emptied into running water used by amphibians for breeding,
2. Nonpoint source pollution such as excess sediment produced from degraded surroundings,
3. High rates of soil erosion and surface runoff resulting in low rates of puddle formation,
4. Air pollution that permeates thin-skinned membranes of amphibians,
5. Destruction of breeding ponds and other ground-level breeding sites through road construction, livestock trampling, heavy grazing, mineral mining, timber harvesting, and recreational developments,
6. Introduction of predatory fish and other amphibian predators into permanent breeding ponds, and
7. Invasion by competing amphibian species. Knowledge of habitat requirements, limits to breeding and survival, and impacts from land use will be needed to recover those amphibian species whose populations are declining at global, regional, or local scales.

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Abundance, species richness, and habitat use of resident land birds of the Lake Pátzcuaro Watershed, Michoacán, México

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Abstract.—The Lake Pátzcuaro watershed, located in north central Michoacán, México, has undergone major shifts and reductions in the quality and quantity of natural resources. Effects of deteriorating environmental conditions on faunal diversity have not been adequately assessed except for a few exceptions such as the endemic white fish (*Chirostoma estor*). We wished to determine bird use of the different watershed habitats and evaluate habitats for avian diversity. Bird counts were conducted during the breeding season in 1994 in seven different habitats found in the watershed including pine-oak woodlands, pine woodlands, oak-pine woodlands, oak woodlands, *Eucalyptus* plantations, pasture communities, and shrubland communities. Sampling effort was distributed among the habitats in proportion to the area they covered in the watershed. A total of 75 count stations were sampled, and 70 species were detected during counts. We found that species richness (mean numbers of species/station) and bird abundance (mean numbers of birds/station) were greatest in pine (5.4 and 7.6, respectively) and lowest in pasture (1.6 and 2.4, respectively). No species occurred in all seven habitat types, while 52% percent of the species were restricted to one habitat. Oak had the greatest number of specialists (12), while plantation had the least (1). Sixty-six percent of the species recorded were insectivores. Patterns of habitat use varied among the foraging guilds.

INTRODUCTION

The Lake Pátzcuaro watershed is an area of high recreational and human use value in north central Michoacán, México. Over the past two decades, the watershed has undergone major shifts and reductions in the quality and quantity of natural resources such as water, topsoil, herbaceous cover, native forests, and other native plant communities and cover types. The watershed has been inhabited for several centuries by the Purepecha Indians, supporting high human populations even before the arrival of the Spaniards. With a current population of more than 100,000 (INEGI 1993), most living in poverty, the natural resources of the watershed have been intensively utilized (Toledo and Barrera 1984). Foreign companies commercially harvested forests throughout the region in the early part of the century, stripping most mountains of the common forest cover type, i.e., open woodlands of large pines (Edwards 1949). Since then, native people have continued harvesting on a small scale, even though a presidential decree forbids timber cutting in the watershed since 1936 (CSE 1987).

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Reduction of natural vegetation and its conversion to agricultural use have resulted in increased soil erosion and deposition of sediments in the lake. Since 1940, depth of the lake has decreased; marshes have increased in area; the endemic white fish (*Chirostoma estor*) has almost disappeared; aquatic weeds (*Eichhornia crassipes*) have become a major problem for fishing and navigation; and waterfowl populations have declined (Arellano and Rojas 1956, CSE 1987). In the uplands, exploitation of forest resources, conversion to agriculture, and extensive cattle ranching, have degraded and endangered wildlife habitats. Effects of deteriorating environmental conditions on faunal diversity have not been adequately assessed except for a few species such as the endemic white fish (Roja and Mares 1988).

The birds of the Pátzcuaro Lake watershed were sampled by a few scientific collectors during the late 1800's. The most important sampling effort occurred in the 1940's, when several American museum expeditions collected birds extensively (Edwards 1949). The first intensive ornithological study in the watershed was conducted by Ernest P. Edwards (Edwards 1949, Lea and Edwards 1950, Edwards and Martin 1955), who recorded 215 species, of which only 71 were confirmed as breeding species. Since Edwards, no data concerning the birds of the Pátzcuaro region are available.

Our study is intended as a contribution to the ongoing ecosystem management efforts focusing on the Lake Pátzcuaro watershed (see the case history in this volume). The primary goal of this paper is to quantify bird use of habitats found in the watershed, and attempt to determine which habitats are important in maintaining avian diversity within the watershed. The contribution of an area or habitat to biodiversity can be assessed by several factors including species richness, abundance of individuals, and unique or restricted species (Langner and Flather 1994). These three factors are used to evaluate watershed habitats and their contribution to biological diversity. Additionally, these preliminary results are part of a statewide "rapid assessment" of biological diversity in Michoacán using birds as an indicator taxon.

In this paper, we report bird count data from 75 sampling stations randomly stratified among seven major vegetation types of the Lake Pátzcuaro watershed. Birds were sampled from 31 May, 1994 to 25 July, 1994. We compared species richness, relative abundance, and foraging guild composition of breeding birds across habitats. We placed species into a foraging guild by the dominate food type they consume. For example, nectarivores eat mainly nectar, although they may also feed on insects. We also examined patterns of specialization in habitat use.

STUDY AREA

The Pátzcuaro Lake basin forms part of the lacustrine system located in the Transverse Neovolcanic Belt, in the northern part of Michoacán. The basin is approximately 100,00 hectares and ranges from 2,000 to 3,300 meters in elevation. The lake covers 10,000 hectares. The basin is bordered by mountain ranges on the west, north, and south (CRAC 1981, Caballero and Mapes 1985, Díaz and Bello 1993). Although the climate is temperate (mean monthly temperature=16°C), with mild winters, several days of below freezing temperatures often occur during December and January. A well-defined dry season extends from November to May, while the rainy season extends from June to October. Annual precipitation is about 1,000 mm (Caballero and Mapes 1985, Díaz and Bello 1993).

Approximately 51% of the land is devoted to agriculture, cattle, and human settlement. Forty-nine percent is covered by primary and secondary natural vegetation. Forest types include pine-oak, oak-pine, oak, pine, with intervening shrublands, grasslands, and forest plantations (Caballero and Mapes 1985).

The pine-oak forest is dominated by *Pinus leiophylla*, *P. michoacana* and *P. lawsoni*, along with *Quercus rugosa*, *Arbutus xalapensis*, and *Alnus jorullensis* (Díaz and Bello 1993). The oak-pine forest is dominated by oaks (*Q. candicans*, *Q. obtusata*, *P. leiophylla*) mixed with scattered pines (*P. pseudostrobus*). The oak forest is dominated by *Q. laurina*, *Q. candicans*, *Q. obtusata*, *Tilia mexicana*, *Meliosoma dentata*, and *Cornus disciflora* in the canopy layer. The pine-oak, oak-pine, and oak forest are the most extensive natural vegetation types in the basin. The pine forest is dominated by *P. montezumae*, *P. teocote*, and *P. leiophylla*. Shrub vegetation is characterized by the presence of

Euphorbia calyculata, Bursera cuneata, Calliandra grandiflora, and *Opuntia tormentosa*. Most of the grasslands are of induced origin and include species such as *Andropogon sacharoides, Bouteloua repens, Digitaria ciliaris*, and *Panicum hallii*. Forest plantations are dominated by a single species, such as *Eucalyptus globulosa* and *Cupressus lindleyi*.

METHODS

A stratified random sampling design was used to locate 75 count stations within the Lake Pátzcuaro watershed. We identified seven habitat types based on a classification utilized in the INEGI Uso del Suelo y Vegetacion, 1:125,000 (1984) map including pine, pine-oak, oak-pine, oak, *Eucalyptus* plantation, shrubland, and pasture. The map was also utilized to estimate the percent area covered by each watershed habitat. The 75 count stations were divided proportionately among the seven major habitats according to the percent area each habitat occupied.

Twenty-five stations were established in the most common habitat, pine-oak forest; 20 stations in oak forest; 10 in oak-pine forest; 5 in pine forest; 5 in *Eucalyptus* plantation; 5 in shrubland; and 5 in pasture. Species were grouped into foraging guilds using various sources as references (Ehrlich *et al.* 1988; Hutto *et al.* 1985; Hutto *et al.* 1986).

The point count method was used to sample birds (Hutto 1986). Counts were conducted from 7:00 to 11:00 am. Birds seen or heard were recorded during a ten minute period at each station. Each station was sampled once. Vegetation was sampled at each count station using methods outlined in Ralph *et al.* (1993). Results of habitat analyses will be reported in future publications. Sampling took place 31 May, 1994 to 25 July, 1994.

In this exploratory analysis, we report bird species composition, numbers of species, overall bird abundance, and numbers of birds per species using each of the seven Pátzcuaro habitats. To standardize tests and results, species richness was summarized as mean (±SE) numbers of species per count station, while abundance was summarized as mean (±SE) number of birds per count station. We used one way ANOVAs to compare species richness, abundance of all birds, and abundance of foraging guilds (omnivore, carnivore, insectivore, granivore, frugivore, and nectarivore) across habitats. Multiple comparisons across habitats were tested using Tukey-HSD tests. The abundance and distribution across habitats among species in different guilds is shown in table form.

RESULTS

A total of 70 bird species were recorded during sampling (Table 1). Of these, 36 (51%) were in only one habitat, 17 (24%) used two habitats, 8 (11%) in three habitats, 3 (4%) in four habitats, 4 (6%) in five habitats, and 2 (3%) in six habitats. No species occupied all seven habitats. Multiple comparisons suggest pasture had significantly lower species richness than the four native forest types (Fig. 1). Pine forest had greatest species richness (5.40±1.1), followed by oak-pine (4.90±0.51), shrubland (4.80±0.37), pine-oak (4.76±0.34), plantation (4.00±0.84), oak (3.55±0.35), and pasture (1.60±0.24).

In comparisons of relative bird abundance, mean numbers of birds/station differed between pasture (fewer birds) and three forest types (Fig. 2). The greatest abundance occurred in pine (7.6±0.68), followed by shrubland (7.4±0.51), plantation (7.2±0.73), oak-pine (7.1±0.92), pine-oak (6.96±0.65), oak (5.1±0.57), and pasture (2.4±0.68).

Patterns of habitat use varied among feeding guilds, and abundance of birds within each guild varied across habitats (Tables 1 and 2). Species composition was dominated by insectivores (46 species) followed by nectarivores (6), granivores (6), frugivores (6), omnivores (3), and carnivores (3) (Table 2).

INSECTIVORES.—Though insectivores were the only guild found in all seven habitats, individual species tended to be restricted to a single habitat (23 species, 50% of 46). In multiple comparisons, insectivores were more abundant in pine-oak than in oak ($F_{6,67}$=2.4;P<.05). Pine-oak was used by 28 (61% of 46) of the detected species, whereas plantation and pasture were used by only 5 (11%) and 7 (15%) species, respectively.

NECTARIVORES.—Species were observed mainly in oak - 5 out of 6 species (83%) - but abundance did not significantly differ among habitats owing to rarity and small sample sizes.

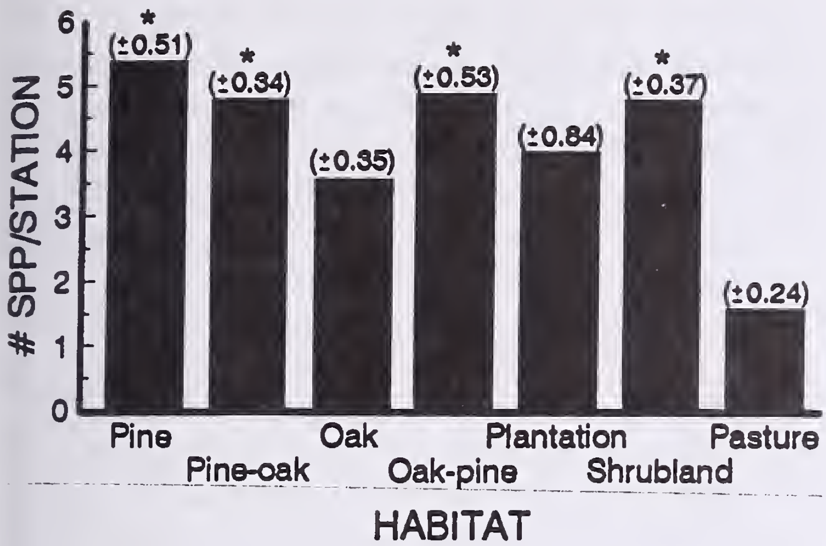

Figure 1. Mean numbers of bird species/station observed in seven vegetation types of the Lake Pátzcuaro watershed. Numbers in parantheses above the bars are standard error of the mean. Asterisks signify a significant difference (P < 0.05, Tukey's HSD test) in numbers of species between pasture and other vegetation types. Paired comparisons between other vegetation types were not significant.

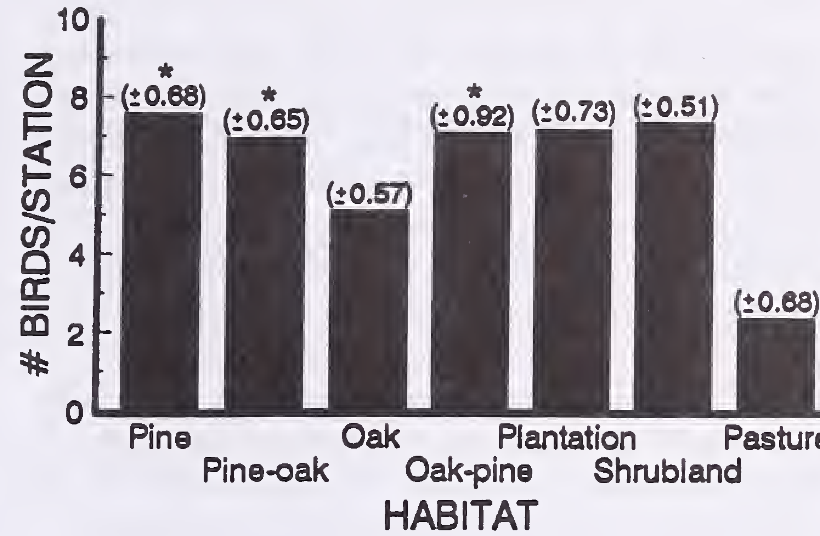

Figure 2. Mean numbers of birds/station observed in seven vegetation types of the Lake Pátzcuaro watershed. Numbers in parantheses above the bars are standard error of the mean. Asterisks signify a significant difference (P < 0.05, Tukey's HSD test) in numbers of birds between pasture and other vegetation types. Paired comparisons between other vegetation types were not significant.

GRANIVORES.—Species richness demonstrated small variation among habitats. Granivore abundance was greater in shrubland, plantation, and pine than in pasture, oak, oak-pine, and pine-oak ($F_{6,67}$=17.0;P<.05). Granivores were also more abundant in pine than in shrubland.

FRUGIVORES.—Although abundance did not significantly vary among habitats, it is noteworthy that species were absent from shrubland and pasture.

OMNIVORES.—Species were confined to four forest types - pine, pine-oak, oak-pine, and oak and were more abundant in oak-pine than oak ($F_{6,67}$=2.1;P<.05).

CARNIVORES.—Birds were found only in shrubland and oak and were more abundant in shrubland than in oak ($F_{6,67}$=2.2;P<.05).

DISCUSSION

Two indicators of biological diversity and habitat value are species richness and number of individuals or abundance. In this study we found that species richness and overall bird abundance were greatest in pine forest and lowest in pasture. Most of the pasture found in the watershed is created and maintained for use by domestic animals.

Another measure of biological diversity is the number of specialists, defined in this study as species restricted to one habitat. Specialists are important because they are especially susceptible to habitat loss. Of 70 species, 36 (51%) used only one of the seven Pátzcuaro watershed habitats. Oak had the greatest number of specialists (12), followed by pine-oak (10), pasture (4), oak-pine (3), pine (3), shrubland (3), and plantation (1). Interestingly, oak had high numbers of habitat-specific species, yet ranked low in species richness and bird abundance. This suggests that oak forest supplied key resources to some bird species, resources that were less common or unavailable in other habitats. An example may be nectar sources, as highlighted by the preference of nectarivores (5 of 6 species) in oak. Pine had few habitat specialists but highest species richness and bird abundance. This demonstrates that pine supplies a wealth of resources to a large number of species and birds even though "unique" resources may not be abundant.

By organizing species into foraging guilds, patterns of species presence/absence potentially related to availability of resources such as food or foraging substrate were identified. The guild with the greatest number of species was the insectivore guild, with 46 species (67% of 70). High numbers

of insectivores in all habitats suggests insects are more readily available than other food types in areas sampled. The frugivore, granivore, and nectarivore guilds, each with only six representative species in total, were less well-distributed across habitats. Nectarivores as a group demonstrated the greatest degree of habitat specialization, with 5 of 6 species found only in oak. Nectar sources may be less common than other food types in other sampled habitats. Because pasture was used only by insectivores, it seems pasture may not be diverse enough in food resources or foraging substrate to attract a rich variety of bird species. This may in part explain why bird species richness was lower in pasture than in all other habitats. Granivores were present in all habitats except pasture, suggesting that seed and grain resources are available (yet not necessarily abundant) in most habitats.

Patterns of species richness and abundance may also be explained in large part by vegetation structure, such as foliage height diversity (MacArthur and MacArthur 1961). These relationships may explain the low species richness and abundance in pasture, which probably exhibits very low vegetative structural diversity. Correlation of habitat data and measures of bird diversity may further explain the observed patterns.

Our findings demonstrated that no single measurement of habitat value can successfully captured the full range of complexity of the Lake Pátzcuaro avifauna. To conserve the biological diversity of the Pátzcuaro watershed, we recommend the use of multiple measures of habitat value that account for marked concentrations and overlapping patterns of: 1) bird abundance, 2) species richness, 3) species endangerment, 4) species specialization in habitat use, 5) species endemism, 6) rates and patterns of population decline, 7) rates of habitat loss, and 8) habitat availability and rarity.

Table 1.—Mean number of birds/station observed in each of seven habitats, and total number of these habitats used by each species. Standard error is shown in parenthesis. Species are listed by guild.

		HABITAT						
GUILD	# of habitats	Pine	Pine-oak	Oak	Oak-pine	Plantation	Shrubland	Pasture
CARNIVORES								
Buteo jamaicensis	1		0.04					
			(0.04)					
Cathartes aura	1						0.60	
							(0.60)	
Glaucidium species	1			0.05				
				(0.05)				
FRUGIVORES								
Catharus aurantiirostris	5	0.20	0.28	0.30	0.10	0.60		
		(0.20)	(0.12)	(0.13)	(0.10)	(0.40)		
Catharus occidentalis	3		0.08	0.15	0.20			
			(0.06)	(0.11)	(0.13)			
Euphonia elegantissima	3		0.16	0.20		0.40		
			(0.09)	(0.20)		(0.24)		
Myadestes obscurus	3	0.45	0.28	0.10				
		(0.15)	(0.11)	(0.10)				
Ptiligonys cinereus	2		0.08		0.40			
			(0.06)		(0.27)			
Turdus assimilis	2		0.16	0.10				
			(0.09)	(0.07)				
GRANIVORES								
Carduelis psaltria	6	2.00	0.12	0.05	0.20	1.00	0.20	
		(0.63)	(0.09)	(0.05)	(0.20)	(0.31)	(0.20)	
Aimophila ruficauda	2	0.20	0.12					
		(0.20)	(0.12)					
Carpodacus mexicanus	2					0.60	1.20	
						(0.60)	(0.20)	

Table 1.—Cont'd.

GUILD	# of habitats	HABITAT Pine	Pine-oak	Oak	Oak-pine	Plantation	Shrubland	Pasture
GRANIVORES—Cont'd.								
Leptotila verreauxi	1	0.20 (0.20)						
Pipilo fuscus	1		0.08 (0.06)					
Zenaida macroura	1	0.20 (0.20)						
INSECTIVORES								
Turdus migratorius	6	0.20 (0.20)	0.56 (0.18)	0.15 (0.08)	0.30 (0.15)	0.40 (0.24)		0.20 (0.20)
Contopus pertinax	5	1.00 (0.32)	0.20 (0.08)	0.30 (0.13)	0.20 (0.20)	0.20 (0.20)		
Myioborus pictus	5	1.40 (0.51)	0.84 (0.20)	0.45 (0.17)	1.50 (0.45)		0.20 (0.20)	
Piranga flava	5	0.60 (0.40)	0.08 (0.05)	0.15 (0.08)	0.10 (0.10)	0.40 (0.40)		
Colaptes auratus	4	0.40 (0.24)	0.04 (0.20)		0.10 (0.10)	0.20 (0.20)		
Pheucticus melanocephalus	4		0.24 (0.10)	0.05 (0.05)	0.20 (0.13)		1.00 (0.31)	
Campylorhynchus gularis	3	0.20 (0.20)	0.08 (0.08)	0.05 (0.05)				
Lepidocolaptes leucogaster	3		0.12 (0.07)	0.05 (0.05)	0.70 (0.26)			
Parus superciliosa	3		0.60 (0.21)	0.40 (0.21)	0.30 (0.15)			
Sialia sialis	3		0.08 (0.08)		0.10 (0.10)			0.60 (0.60)
Trogon elegans	3	0.40 (0.24)	0.16 (0.08)		0.50 (0.22)			
Basileuterus rufifrons	2		0.08 (0.06)	0.10 (0.10)				
Empidonax species	2		0.08 (0.08)	0.10 (0.10)				
Ergaticus ruber	2		0.12 (0.09)	0.05 (0.05)				
Hirundo rustica	2					1.00 (1.00)	1.80 (0.97)	
Mimus polyglottos	2		0.12 (0.09)		0.20 (0.13)			
Myioborus species	2		0.04 (0.04)				0.20 (0.20)	
Myioborus miniatus	2		0.32 (0.11)	0.25 (0.12)				
Parus sclateri	2		0.28 (0.24)	0.40 (0.31)				
Psaltriparus minimus	2		0.28 (0.28)				0.40 (0.40)	
Vireo species	2		0.12 (0.33)	0.25 (0.20)				
Vireo huttoni	2			0.05 (0.05)			0.20 (0.20)	
Xenotriccus mexicanus	2		0.08 (0.08)	0.05 (0.05)				

Table 1.—Cont'd.

GUILD	# of habitats	Pine	Pine-oak	Oak	Oak-pine	Plantation	Shrubland	Pasture
		HABITAT						
INSECTIVORES—Cont'd.								
Agelaius phoeniceus	1							0.40 (0.24)
Atlapetes virenticeps	1		0.08 (0.08)					
Certhia americana	1			0.05 (0.05)				
Dendroica graciae	1	0.20 (0.20)						
Empidonax affinis	1			0.05 (0.05)				
Empidonax difficilis	1			0.05 (0.05)				
Icterus parisorum	1							0.20 (0.20)
Icteria virens	1						1.40 (0.24)	
Junco phaeonotus	1		0.12 (0.09)					
Lanius ludovicianus	1		0.04 (0.04)					
Melanerpes aurifrons	1						0.20 (0.20)	
Molothrus aeneus	1		0.04 (0.04)					
Myiozetetes similis	1			0.05 (0.05)				
Myiarchus tuberculifer	1		0.04 (0.04)					
Passerina species	1			0.10 (0.10)				
Passerina versicolor	1			0.05 (0.05)				
Picoides villosus	1				0.10 (0.10)			
Pyrocephalus rubinus	1				0.10 (0.10)			
Sitta carolinensis	1		0.04 (0.04)					
Sturnella magna	1						0.20 (0.20)	
Stelgidopteryx serripennis	1		0.16 (0.09)					
Tachycineta thalassina	1					2.40 (0.40)		
Toxostoma curvirostre	1							0.40 (0.40)
NECTARIVORES								
Hylocharis leucotis	2		0.08 (0.08)		0.50 (0.22)			
Amazilia beryllina	1			0.25 (0.18)				
Cynanthus latirostris	1			0.05 (0.05)				

Table 1.—Cont'd.

GUILD	# of habitats	HABITAT Pine	Pine-oak	Oak	Oak-pine	Plantation	Shrubland	Pasture
NECTARIVORES—Cont'd.								
Eugenes fulgens	1			0.05				
				(0.05)				
Lampornis species	1			0.05				
				(0.22)				
Lampornis clemenciae	1			0.10				
				(0.07)				
OMNIVORES								
Corvus corax	4	0.40	0.20	0.05	0.90			
		(0.24)	(0.10)	(0.05)	(0.55)			
Melanotis caerulescens	1				0.20			
					(0.20)			
Melanerpes formicivorus	1		0.24					
			(0.12)					

Table 2.—Mean number (±SE) birds/station in six foraging guilds across seven habitats, and one-way analysis of variance of bird numbers among habitats within each guild.

GUILD	# of habitats	HABITAT Pine	Pine-oak	Oak	Oak-pine	Plant-ation	Shrub-land	Pas-ture	F	df	P
CARNIVORES	3			0.05			0.60		2.24	6,67	0.05
				(0.05)			(0.60)				
FRUGIVORES	6	0.20	1.04	1.20	0.80	1.00			1.72	6,67	0.13
		(0.45)	(0.21)	(0.28)	(0.42)	(0.55)					
GRANIVORES	6	2.60	0.32	0.05	0.20	1.60	1.40		16.96	6,67	0.00
		(0.40)	(0.15)	(0.05)	(0.20)	(0.40)	(0.24)				
INSECTIVORES	46	4.40	4.68	2.70	4.40	4.60	5.40	2.50	2.43	6,67	0.04
		(1.12)	(0.39)	(0.48)	(0.88)	(0.93)	(0.87)	(0.87)			
NECTARIVORES	6		0.08	0.50	0.50				1.53	6,67	0.18
			(0.08)	(0.22)	(0.22)						
OMNIVORES	3	0.40	0.44	0.05	1.10				2.12	6,67	0.06
		(0.24)	(0.18)	(0.05)	(0.55)						

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The Ouachita Mountains Ecosystem Management Project: A case study of the linkage between research and management

James M. Guldin, James B. Baker, John M. Curran, and William Pell[1]

ABSTRACT.—The Ouachita Mountains Ecosystem Management Project is a joint research and management effort designed to generate scientific support for ecosystem management in the Interior Highlands of Arkansas and Oklahoma, U.S.A. The three-phase program is a case study about how people in research and management can work together to build public acceptance, management innovations, and a productive research environment. The program is highlighted by partnerships with scientists, land managers, public advisory groups, and the public at large. The research itself is characterized by an interdisciplinary approach in which many topics are studied concurrently, often using the same sample plots. A major key to success has been the placement of research scientists and managers at the same location, which promotes scientists' access to management operations and managers' access to research expertise.

INTRODUCTION

The Ouachita Mountains Ecosystem Management Project is a multiagency effort in research and management, located on the Ouachita National Forest in the Interior Highlands of western Arkansas and eastern Oklahoma. The project is highlighted by a three-phase research program administered through the U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, and also includes several large-scale demonstration projects and innovative methods of forest management. The project originated in conjunction with the emphasis on ecosystem management in the Forest Service and is a case study that illustrates how national forest managers can work in partnership with scientists to ensure that management practices are based on the best scientific research available.

EXPERIMENTAL APPROACH

The centerpiece of the project is the research program, the goal of which is to provide scientific support for ecosystem management in the Interior Highlands into the next century. The research program is divided into three phases of increasing scale, designed for flexibility and innovation as we learn more about ecosystem management.

Phase I: Demonstration Stands

In Phase I, now complete, scientists and managers installed stand management demonstrations in the field to illustrate stand-level considerations in ecosystem management. These demonstration stands are designed to show alternatives to clearcutting and planting, such as even-aged and

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uneven-aged partial cuttings, natural regeneration, minimal site preparation, and long-term retention of a mixed-species overstory (figs. 1, 2). These demonstration stands are extremely valuable, because they provide Forest Service leaders, key political officials, and citizens from all walks of life with an in-the-woods view of the emerging philosophy and practical application of ecosystem management.

Phase II: Stand-level Scientific Study

Phase II is a replicated and operationally imposed scientific study that consists of fifty-two 35-acre stands (13 treatments × 4 geographic blocks) designed to study the effects of partial cutting for natural regeneration at the stand-level scale. Phase II includes retention of a mixed-species overstory (pines and hardwoods are retained after reproduction cutting), low-intensity site preparation and release (including a test of no site preparation and no release), and the indefinite retention of residual overstory trees. Now in its first posttreatment growing season, Phase II features the work of nearly 60 research scientists from the Forest Service, universities, and industry, organized into 7 interdisciplinary research groups.

Phase III: Landscape-scale Scientific Study

Phase III is designed to study ecosystem management at scales that transcend the individual stand, such as watersheds and landscapes. The objective of Phase III is to evaluate sustainable ecosystem management across landscapes having different forest patterns. Of special emphasis are the cumulative effects of management actions on large-scale ecosystem structure and function, with special emphasis on basin hydrology, critical species of flora and fauna in both terrestrial and aquatic systems, and the social context of landscape-based management actions.

KEY ELEMENTS

Partnerships

Both Southern Station scientists and national forest liaison personnel are located in research headquarters at the national forest supervisor's office. National forest personnel directly support research through staff decisions, environmental analyses, budgets, and ranger district operations in the experimental stands. The research team in-

Figure 1.—An even-aged, partial cutting alternative to clearcutting and planting: Modification of shelterwood reproduction cutting method, in which pines and hardwoods are retained in the overstory.

Figure 2.—An uneven-aged, partial cutting alternative to clearcutting and planting: Modification of the single-tree selection reproduction cutting method, in which pines and hardwoods are retained in the overstory.

cludes over 60 scientists from 9 Forest Service research work units and more than a dozen universities, coordinated by the team leaders for research and Station administrators.

People with different areas of interest are also an important element of the research. The Ouachita National Forest Ecosystem Management Advisory Committee played a role in having researchers emphasize studies in ecology, resources, and the social context. Citizen involvement is essential for planning research such as this; researchers and managers alike have been enlightened during extensive discussions with a spectrum of interest groups and individuals. Finally, forest industry, a traditional client, continues to play an active role in giving advice regarding experimental design and industry interests.

Interdisciplinary Research

Seven research groups comprise Phase II: silviculture, wildlife, understory plant diversity, soils and water quality, arthropods and microbial diversity, logging/economics, and visual quality. Five research groups comprise Phase III: vegetation ecology, wildlife ecology, hydrology, aquatic ecology, and social science. These groups, together with research leaders, plan interdisciplinary studies using the same stands and watersheds; they also share data and provide a more complete experimental method than possible through the traditional "one scientist, one study" approach.

Mutual Exchange Between Research and Management

Among the unexpected benefits has been research scientists and managers working together closely on a daily basis. This provides opportunities for each to learn from the other. For example, all 52 Phase II stands were marked for experimental harvests in 1992 by personnel from Ouachita National Forest ranger districts, using guidelines supplied by the researchers. Many of these marking standards are now being regularly used by the ranger districts. Scientists also regularly participate in national forest program reviews and policy discussions. This interaction between scientists and managers leads to an adaptive management process in which the information gained through research is applied to operational field and management practices.

Research scientists have also learned from managers. The research plans were constantly adjusted to better reflect the actual conditions under which management decisions occur, and especially, to bring the research into compliance with the necessary laws and regulations that govern national forest management.

As the studies continue, plans are to produce results through computer models and continuing education programs targeted for national forest managers and field crews. It will be important for researchers and managers to work together at this stage also, so that research results are meaningful and applicable in the forest.

THE FUTURE

The Ouachita Mountains Ecosystem Management Project provides a case study for the benefits that result when scientists and managers work cooperatively toward a common goal. The Phase I demonstrations have been extremely helpful in visualizing management alternatives. The Phase II stand-level experiments will give detailed results over the next decade that will help managers apply these alternatives in a scientifically sound manner, and will generate results for the next decade. The Phase III landscape study should produce similarly detailed results, hopefully over the next two decades. In combination, this three-phase approach illustrates a successful method of developing scientific support and social acceptance for ecosystem management in the Ouachita Mountains.

Road derived sediment in El Carrizal watershed, Tapalpa, Jalisco, Mexico

Lucas Madrigal Huendo[1], Yolanda Chávez Huerta[2], and Daniel G. Neary[3]

Abstract.—The objective of this paper is to examine roads as a source of sediment for the El Carrizal stream. This watershed lies in the Sierra de Tapalpa mountain system near Tapalpa, Jalisco, Mexico. The temperate forest is composed mainly of species of *Pinus* and *Quercus*. Elevations range from 2,000 to 2,420 m. The mean annual rainfall is 903 mm, with most occurring during the June to October rainy season. The streamflow regime is baseflow dominated and perennial. The road network consists of: 1) main roads on the perimeter of El Carrizal, and along the main stream channel; and 2) smaller, temporary access roads linking to the main system. Road surfaces range from gravel and crushed rock to bare soil. There is only one area with active gully systems within El Carrizal. It lies along the left perimeter main road in a zone of highly erosive rhyolite. This gully system is a good example of situations where soils and geology (weathered rhyolite) interact with land management activities (roads) to produce zones of high erosion hazard. Estimates of sediment volumes were obtained using level surveys and direct dimensional measurements of eroded areas, sediment traps, and debris dams. Conclusions from this study are: 1) The El Carrizal is basically in good watershed condition; 2) Roads are the main source of sediment entering streams (some gullys along roads have eroded rapidly, losing 300 m^3 of soil in 2 years); 3) A number of low cost methods (berms, sediment traps, check dams, wing ditches, broad-based dips) can be used to prevent excessive road erosion and preserve the quality of El Carrizal's stream.

INTRODUCTION

A very important product of well-managed, sustainable, forest ecosystems is high quality, continuous water flow. This resource is important for human use in cities, agriculture, and recreation. The demand for water is constantly growing as populations increase and water-intensive agriculture and manufacturing enterprises expand. In addition, sustainable flows of good quality water are necessary to support diverse and healthy populations of aquatic and terrestrial biota. So, maintaining the quality and quantity of water flow is a crucial component of sustainable forest management.

"Watershed Condition" is a concept used to assess the relative ability of a watershed to receive precipitation and deliver it to a landscape as streamflow or groundwater. Watersheds in "good" condition are noted for:

- Streamflow that is mainly baseflow and perennial;
- Good water quality; and
- Minimal sediment transport.

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Watersheds in "poor" condition usually have:

- Streamflow that is flashy, stormflow dominated, and ephemeral;
- Poor water quality; and
- High sedimentation.

Most well-managed forests have "good" watershed condition. However, an important aspect of sustainable forest management is developing an awareness of sensitive zones, and activities that can result in the quick deterioration of good watershed conditions.

Roads are major erosion hazard zones that can produce quick deteriorations in watershed condition and water quality. Being bare soil or rock areas, they are sources of surface runoff and sediment that can quickly enter streams. The term "roads" includes temporary logging access roads and log extraction trails as well as permanent transportation system main and secondary roads. For temporary roads, most erosion occurs within two-to-four years of the initial disturbance. Permanent roads are continual sources of sediment, but the amount of sediment they generate depends on a number of factors.

The amount of sediment produced by a road is a function of road design, location, construction, surface and fill materials, use, and maintenance interacting with topography, hydrology, and climate. In most parts of North America and the world, road construction accounts for the largest amount of silviculture-produced sediment (Brown 1972). Surface erosion on poorly-built and improperly maintained forestry roads can exceed amounts documented on severely eroded agricultural areas (Megahan 1987). Consequently, a number of Best Management Practices for road construction and maintenance have been developed (Burns et al. 1995, Hynson et al. 1982, North Carolina Division of Forest Resources 1989, Ontario Ministry of Natural Resources 1988, Rothwell 1978, Swift 1985, etc.).

The whole process of minimizing sediment loss from roads begins with proper design, adequate construction scheduling, and sufficient engineering supervision (Larse 1971, Swift 1988). The purposes of these practices are to minimize soil loss from raindrop impact, frost heave, and dry ravel; prevent downslope soil movement due to mass failures; and reduce erosion from roadbeds. Some sediment-reducing road design features are listed in Table 1. King (1984) documented a decrease in sediment yield from 156 to 19% with good road construction technique. The selection of surface materials alone can make significant reductions in sediment losses of 70 to 99% (Kochenderfer and Helvey 1984, Megahan 1987, and Swift 1984).

Some key methods for erosion reduction during use of road systems are listed in Table 1. Soil movement off of a road site can be reduced 24 to 99% with these techniques (Megahan 1980 and 1987, Swift 1986). The materials and labor costs associated with these methods are highly variable, depending on type, material availability, machinery requirements, and labor needed. Burns et al. (1995) discuss a number of low-cost techniques for controlling sediment movement. They estimate that the use of ditch outlets, sediment traps, berms, berm openings, outsloped roads, humps, and relief culverts will prevent about 75% of the sediment associated with roads from ever reaching streams.

Road maintenance procedures are very important for keeping erosion at a low level (Table 1). Poorly maintained roads develop wheel ruts that can channel runoff along the road surface instead

Table 1. Erosion control during design, construction, use, and maintenance of forest roads

1. Design and Construction Techniques
   a. Schedule to avoid wet seasons
   b. Design to minimize stream crossings
   c. Layout an adequate stream buffer strip
   d. Construct crossings and install culverts during low flow
   e. Minimize sidecast of excavated material
   f. Design outslopes, broad-based dips, or crowns for drainage
   g. Install turnouts, traps, berms,relief culverts, and humps
2. Sediment Movement Control Measures During Use
   a. Native vegetation, grass, and legume seeding\establishment
   b. Brush barrier construction
   c. Silt fence installation
   d. Rock riprap layering
   e. Hydromulching and straw and wood chip mulching
   f. Rock\gravel surfacing of high erosion hazard areas
   g. Litter and vegetation filtering in buffer strips
3. Road Maintenance Procedures
   a. Grading to retain designed surface and drainage shape
   b. Clearing ditches, culverts, sediment traps, turnouts, etc.
   c. Resurfacing or patching deteriorated sections
   d. Closing or restricting access on unneeded roads
   e. Creating broad-based dips or building water bars
   f. Periodically inspect both closed and open roads

of off the road into a ditch or the forest floor. Ditches, culverts, traps, and turnouts that are sediment clogged cannot function properly. Then, their value for sediment control is negligible, and they may in fact aggrevate erosion.

The objective of this paper is to examine roads as a source of sediment for the El Carrizal stream. Recommendations are made for sustaining good water quality during multiple resource management.

METHODS

Study area

The El Carrizal watershed lies in the Sierra de Tapalpa mountain system near Tapalpa, Jalisco, Mexico (Figure 1). The watershed encompasses 1170 ha, of which 762.7 ha are above the 120 degree V-notch weir (Figure 2).

The temperate upland forest overstory is composed mainly of species of *Pinus* and *Quercus*. *Pinus michoacana*, *P. douglasiana*, *Quercus resinosa*, *Q. rugosa*, and *Q. obtusata* are the predominant tree species (Gómez Tagle and Chávez Huerta 1986). The understory is variable, consisting of shrubs, grasses, or herbaceous plants.

In the riparian zone, the vegetation consists of mesophyllic montane forest, with the most common tree species being *Rhamnus mucronata*, *Viburnum stellatum*, *Phoebe arsenei*, *Salix bonplandiana*, *S. oxylepis*, *Fraxinus* spp., *Prunus bonplandiana*, *S. oxylepis*, *Prunus bachybotrya*, *Prunus serotina* var. *capuli*, *Cornus excelsa* and *Alnus* spp. The number of layers of vegetation strata is variable. Like the upland forest, the understory is variable, consisting of shrubs, grasses, or herbaceous plants (Madrigal-Sánchez et al. 1995).

Figure 1. El Carrizal Watershed Location, Tapalpa, Jalisco, Mexico.

Forests in this region of Mexico have been significantly altered since Spanish colonial settlement in the 1600's. Periodic forest harvesting, grazing, and burning have been occurring for nearly 400 years. Major wildfires burned the upper portions of El Carrizal in the 1900's and 1950's.

Elevations range from 2,000 to 2,420 m. The mean annual rainfall is 903 mm, with most occurring during the June to October rainy season. Monthly precipitation ranges from 170 mm in July to 7 mm in February. The streamflow regime is baseflow dominated and perennial (Baker et al. 1995).

The geology of the watershed is diverse, containing mostly Cenozoic igneous rocks from volcanic eruptions over the past 8 million years. The primary mineralology ranges from iron-rich basalt to siliceous rhyolite, but basalt is the predominant rock type (Figure 3). The lower reaches of El Carrizal used for agriculture are alluvial in nature. A small area of shale and sandstone outcrops is located on the right side of the watershed. These sedimentary formations are buried elsewhere by the Cenozoic volcanics. The drainage pattern of El Carrizal is dendritic, with most first- and second-order streams flowing intermittently.

Soils are mainly Regosols (Andosols) overlying deeply weathered saprolite (Figure 4; Gomez Tagle and Chavez Huerta 1986). Inclusions of Luvisols, Feozem and Cambisols occur mainly at lower elevations. The Regosols are highly erosive but deeply weathered. Isovolumetrically weathered saprolite beneath the solum extends below a depth of 4 m (Figure 5). Areas of low infiltration capacity due to bedrock outcrops or durapans are relatively small within the forested zone of El Carrizal.

The undisturbed nature of the forest floor throughout El Carrizal, deep soils and saprolite, and a minimum of eroded, rocky, or impermeable surface runoff areas create an excellent watershed condition. The weathered rock beneath the soil (saprolite) also adds to the excellent watershed condition of El Carrizal. During the weathering process there is a loss of primary minerals and creation of voids with no loss of volume (isovolumetric weathering). This process creates a huge storage capacity for the rainfall that infil-

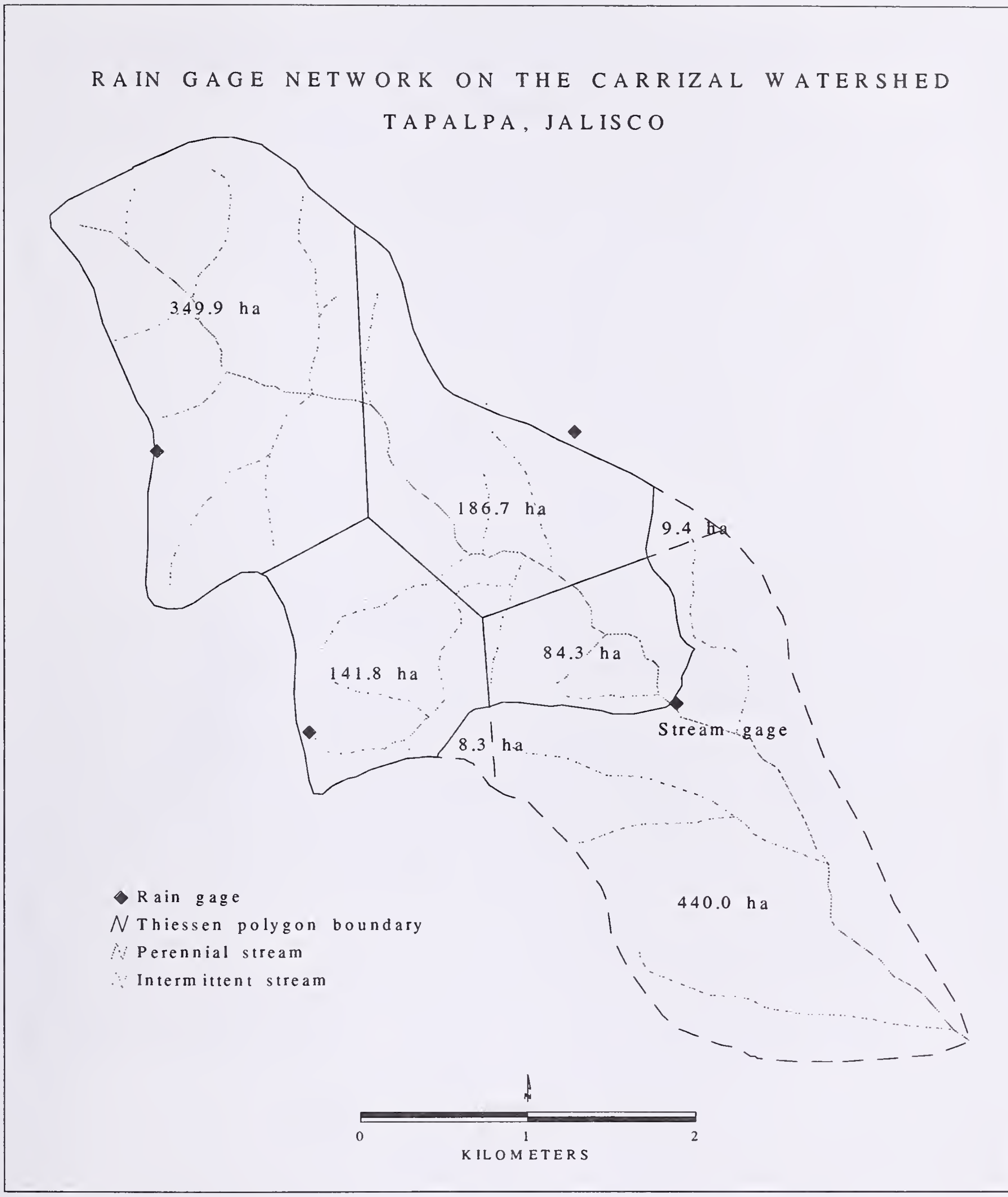

Figure 2. Rain network on the gage Carrizal watershed, Tapalpa, Jalisco, with stream gage, stream channels, and theissen areas.

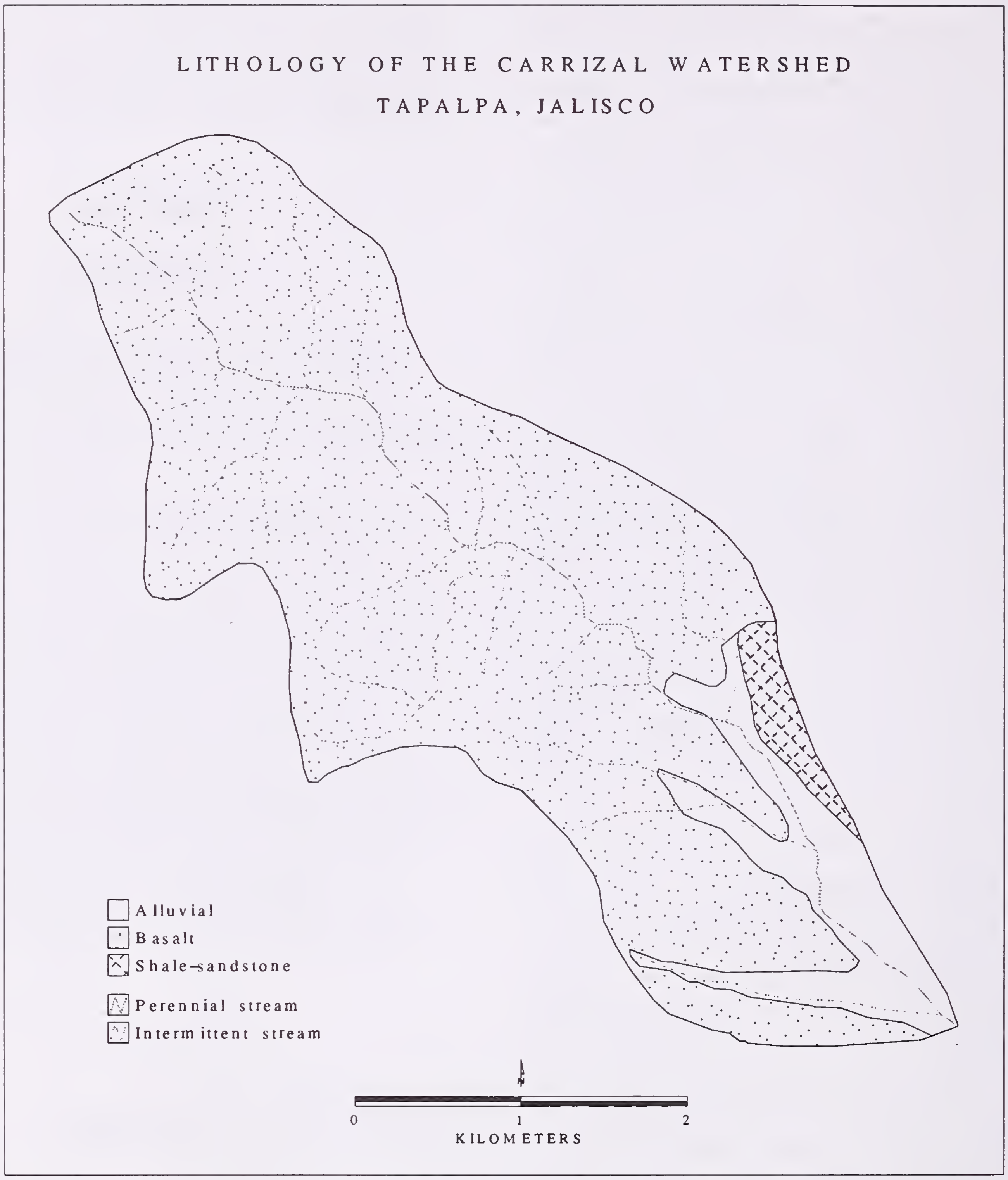

Figure 3. Lithology of the Carrizal watershed, Tapalpa, Jalisco.

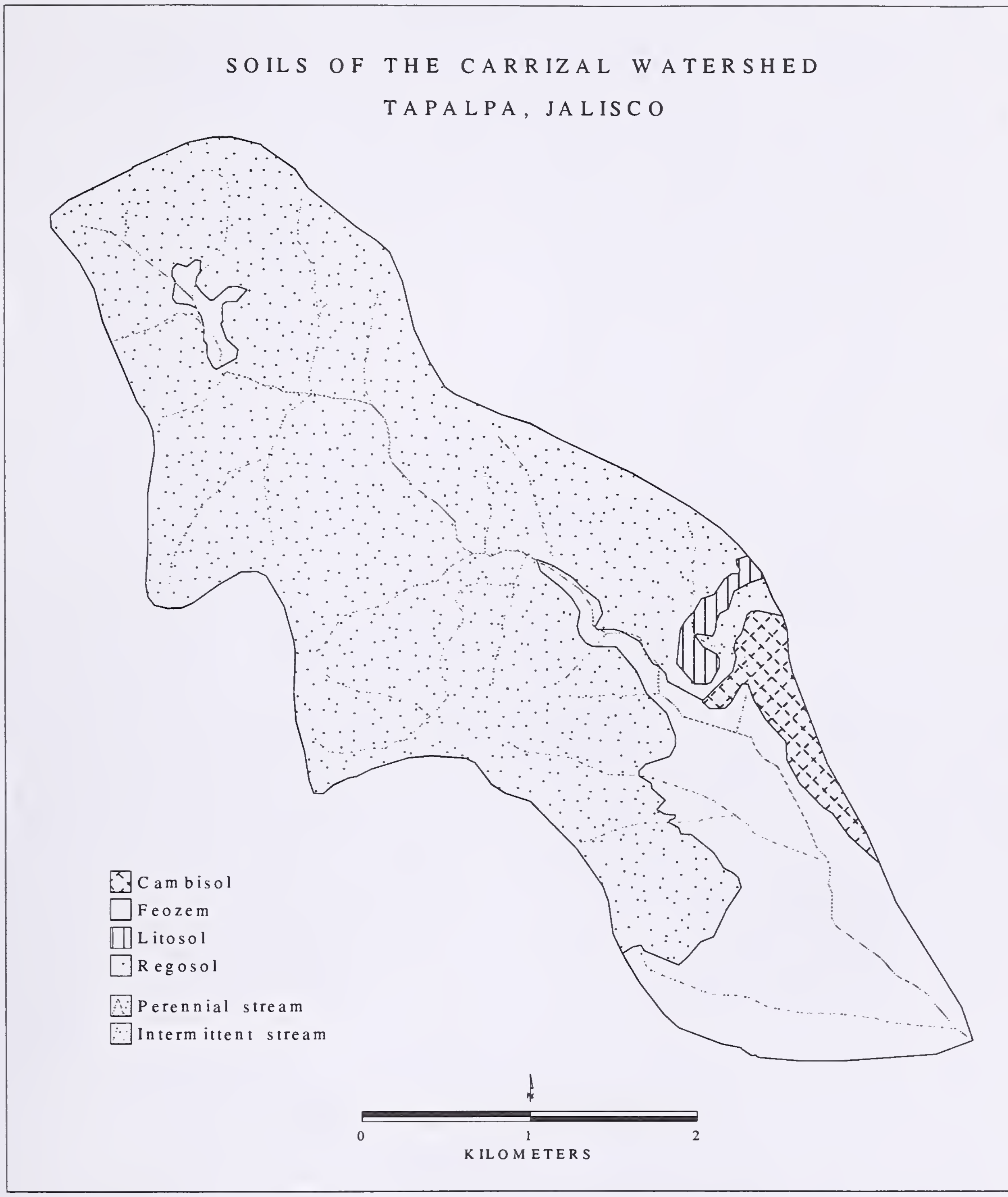

Figure 4. Soils of the Carrizal watershed, Tapalpa, Mexico.

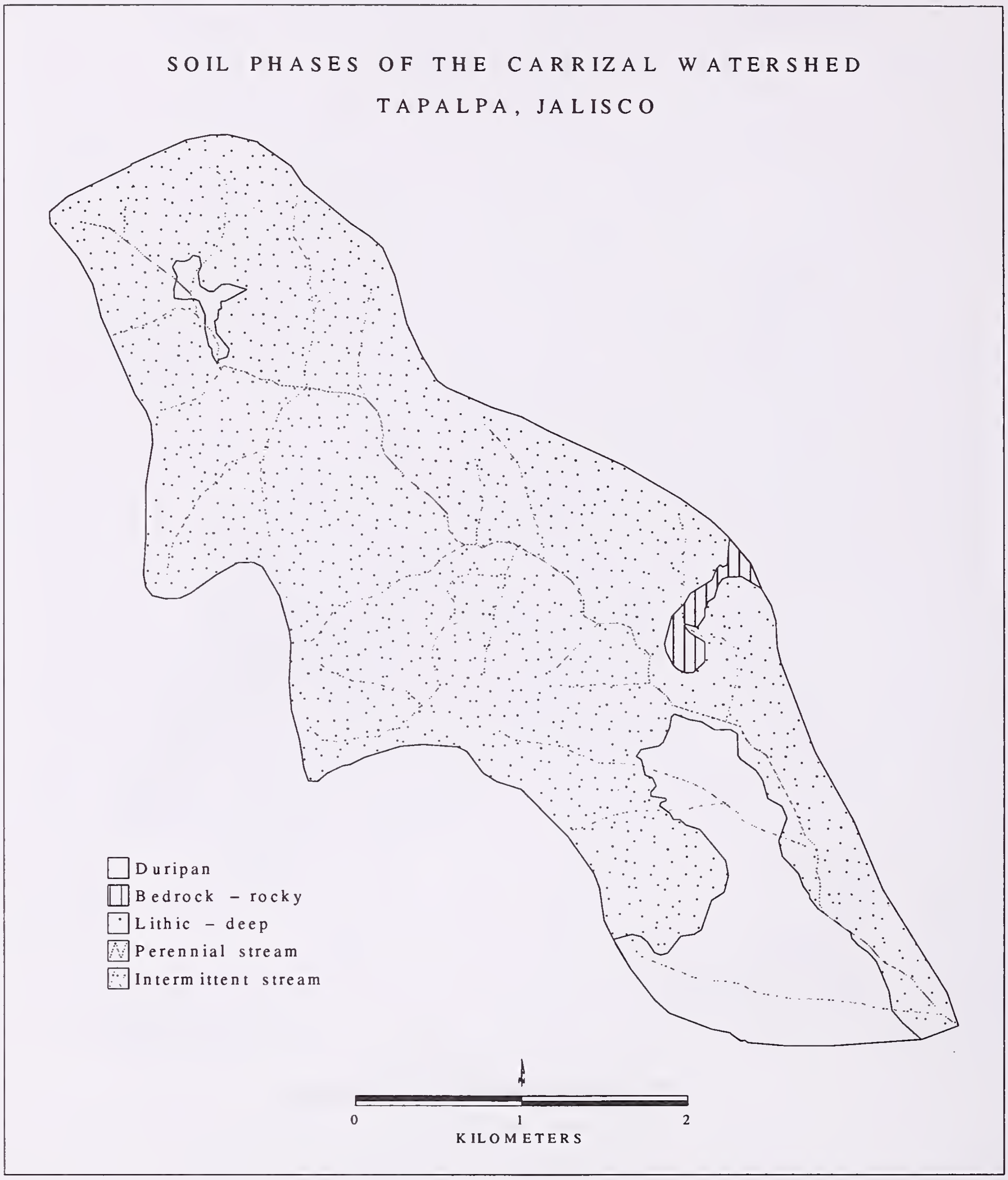

Figure 5. Soil phases of the Carrizal watershed, Tapalpa, Jalisco.

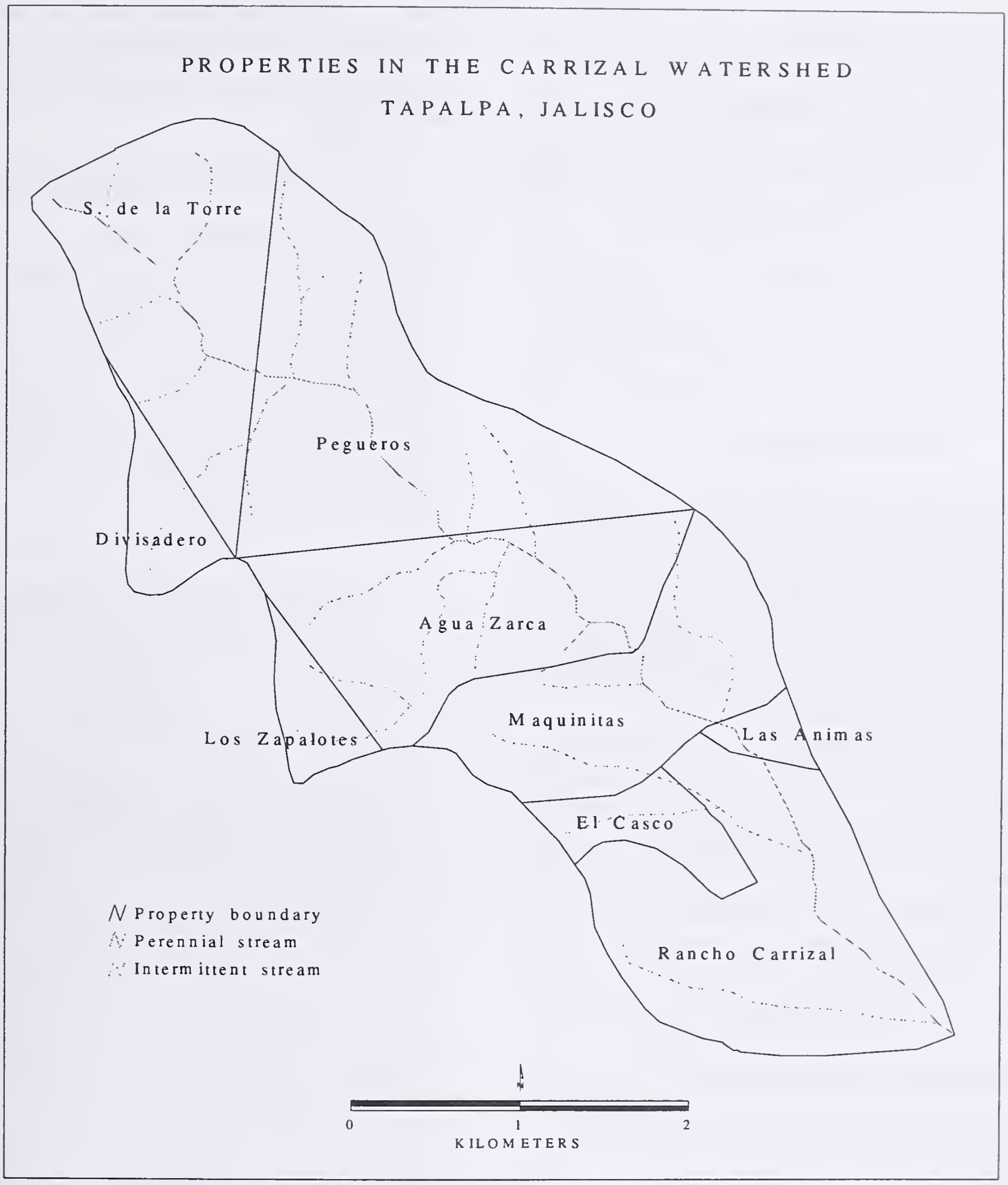

Figure 6. Properties of the Carrizal watershed, Tapalpa, Jalisco.

trates into the soil. This stored water, in turn, feeds the perennial flow of the stream that is indicative of excellent watershed condition and baseflow-dominated hydrology.

Road network

The road network consists of: 1) main roads on the perimeter of El Carrizal, and along the main stream channel; 2) smaller, temporary access roads linking to the main system; and 3) logging skid trails. Road surfaces range from gravel and crushed rock to bare soil. The roads in the El Carrizal watershed were surveyed to determine total length using a wheel odometer. The roads were classed into "Good", "Medium", and "Bad" condition depending on: 1) surface material, 2) amount of surface rutting; and 3) depth of entrenchment.

Gully systems

A complete reconnaissance of the watershed was conducted to locate actively eroding gully systems. There is only one major area with active gully systems within El Carrizal. It lies along the left perimeter main road in a zone of highly erosive rhyolite. This location is a good example of situations where soils and geology interact with land management activities to produce zones of high erosion hazard. A section of the left perimeter road (now abandoned) dumped runoff onto an area of highly erosive, weathered rhyolite. Continued erosion not only transports a lot of sediment, but also threatens to undermine the existing road.

Another gully system of unknown age, located on the right perimeter road, has been stabilized by forest vegetation. The road adjacent to this gully system is currently undergoing moderate-to-severe erosion. Another gully has developed in the past two years along the lower portion of the riparian access road (Las Maquinitas road).

Erosion control

Several different techniques for controlling sediment movement have been implemented in the past year on the El Carrizal watershed. Along the roads, ditch outlets, sediment traps, humps, and rock check dams have been installed (Burns et al. 1995). Both rock and wood check dams have been built in some of the major gully systems.

In the past, permeable, low water, stream crossings made of columnar basalt were built in several locations instead of bridges. These stream crossings have been efficient in trapping sediment, aggrading 2-3 m over several decades. The crossings were elevated by adding additional courses of stone as more sediment was trapped. Two of these structures have been built near rock mines along the El Carrizal stream where significant erosion is occurring.

Erosion measurements

Estimates of sediment volumes were obtained using level surveys of length, width, and depth of entrenchment. Direct dimensional measurements of gullies were done on the left perimeter road gully system in 1994. Level surveys have been completed on part of the upper right road and the lower road. Erosion volume estimates were converted to mass using an average density of 2,000 kg/m^3 (Hooke 1994).

RESULTS AND DISCUSSION

Roads

Network

The road system, excluding skid trails, within the property boundary that includes El Carrizal's forested area and that of the adjacent La Hacienda watershed, amounts to 54.5 km (Figure 6; Table 2). Considering average road widths of 3-4 m, this is about 2% of the forested surface area of both watersheds. Except for 3 small rock mines, and channel and streambank erosion, about 2% of the land area is responsible the bulk of the sediment produced in El Carrizal. Sediment contributions of the mines and channels\streambanks have not been measured. Sediment production from geomorphic processes such as channel adjustment and bank erosion can range from 110 to 220 kg/ha in humid regions.

Table 2. Forest main road length within the property unit that includes parts of El Carrizal and La Hacienda watersheds.

Land parcel	Road length (meters)
EL CARRIZAL	
1. Pegueros	8,866
2. Agua Zarca	9,018
3. Maquinitas	2,715
4. El Casco	759
5. Las Animas	798
EL CARRIZAL AND LA HACIENDA	
6. Divisadero	9,263
7. Los Zapalotes	11,107
LA HACIENDA	
8. Ojo de Agua	2,999
9. La Pitilla	3,551
10. Other Access Roads	5,460
TOTAL ROAD DISTANCE	54,536

Upper Road Erosion

Along right boundary road in the Pegueros parcel, there are two eroded sections that are entrenched into the slope. Each section is separated by a level bench. The road runs straight uphill and parallels the stabilized gully system discussed in the Methods above. The lower of the two sections is 180 m long. Its exact age is not known, but it is probably less than 10 years old. It was surveyed in February, 1994. About 1,400 m^3 of soil (2,800 Mg or metric tons) has eroded out of this lower section. Sediment losses for both sections combined probably amount to 5,000 to 6,000 Mg. Most of the sediment appears to have deposited on low-gradient benches below the eroded road sections instead of in the ephemeral stream channels.

Lower Road Erosion

A long gully developed along the uphill drainage ditch of the road that leads from the Rancho Carrizal parcel into the Maquinitas riparian road. It formed rapidly in the ditch line in the past 2 years, channeling water about 650 m downslope. The lower portion consists of an active, widening gully while the upper portion is still recognizable as a ditch. A level survey completed in February, 1994, indicated that about 300 m^3 (600 Mg) of sediment eroded out. Most of this detached material was redeposited on pastures in the Rancho Carrizal parcel. During rainfalls, copious amounts of suspended sediment flow out of this gully system.

Gullies

Two types of sediment check dams were installed in the severely eroded area along the left boundary road to determine their function and the rate of sediment entrapment. Six check dams were constructed out of branches along a 145 m section of road with developing ditch gullies. In three months during the rainy season they trapped 1.46 m^3 (about 2.9 Mg). In the larger gullies (up to 5 m deep), four sediment check dams made of small logs were installed along 297 m of gully. In the same three months they accumulated 7.49 m^3 of sediment (about 15 Mg)

These preliminary results indicate the amounts of sediment eroding off of road surfaces. They also show how much sediment can be trapped and stabilized by relatively low cost techniques and structures. This is discussed in more detail by Burns et al. (1995).

Mines

At the present time there are not any good estimates of sediment losses from three rock mines. One of the largest mines is located right next to the perennial stream channel of El Carrizal. The second is on the right perimeter road about 1 km from the main stream channel, and the third (inactive) is located just downstream of the first.

Low water stream crossings

There are several low water stream crossings made of columnar basalt located in the El Carrizal watershed. These crossings are essentially permeable barriers. They function well in providing an inexpensive yet functional load-bearing surface for vehicles, and in trapping bedload sediments. Several older crossings have accumulated 2-3 m of sediment behind them. Two new ones were constructed in 1994 to retain sediments associated with the rock mines. One was built in the main stream and the other was constructed at the base of

a small rock mine where sediments were moving into the stream unimpeded. The rate of sediment accumulation is being monitored. The one near the small mine accumulated 1.44 m^3 in three months.

Comparison

Some reference sediment loss values are presented in Table 3 (From Neary and Hornbeck 1994). The geologic erosion values are representative of large landscapes (>10,000 ha). The remainder are from gaged watersheds <1,000 ha). In both the eastern and western USA, sediment losses from undisturbed watersheds are remarkably similar. There are some exceptions related to local geology and geomorphic processes. The largest losses are linked to human activities, as indicated in the analysis by Hooke (1994).

The El Carrizal stream, has a low bedload component and high suspended sediment component. The watershed above the weir is relatively stable and undisturbed at the moment, so a mid-range sediment yield value for undisturbed forest watersheds was selected to calculate El Carrizal's channel losses (Table 4). This produced an estimate of 232.5 Mg/yr for 762.7 ha. The other sediment loss estimates clearly illustrate an important feature documented in many other places. Relatively small areas of the landscape associated with roads or gullies initiated by roads, produce an inordinately large amount of sediment. The amount of sediment lost out of 0.5 ha of road on the right perimeter of the watershed is equivalent to channel losses from the entire watershed for about 24 years. So, the key to sustaining water quality in El Carrizal is control of road erosion.

Table 3. Sediment Loss Comparisons (From Neary and Hornbeck 1994).

Source		Loss (Mg/ha/yr)
1. USA		
Geologic Erosion	Low	0.6
	High	15.0
2. Eastern USA		
Undisturbed Forests	Low	<0.1
	High	0.6
3. Western USA		
Undisturbed Forests	Low	<0.1
	High	0.5
4. Eastern USA		
Forest Road Construction		140.0
5. USA		
Maximum Cropland Loss Tolerance		11.2
Agricultural Land Losses	(High)	13.0
6. USA		
Intensive Forestry Site Preparation		15.0
7. CHINA:		
Uncut Forest - Hong Kong		2.0
Clearcut Forest - Hong Kong		97.0
8. NEW ZEALAND		
Uncut Forest - Westland		0.4
Clearcut Forest - Westland		3.4

Table 4. A comparison of sediment losses in El Carrizal watershed

Source	Loss (Mg)	Area (ha)	Period
1. El Carrizal Channels	232.5	762.7	1 year
2. Right Perimeter Eroded Road	5,600.0	0.5	Unknown
3. Lower Road	600.0	0.3	2 years
4. Left Perimeter - Road	2.9	0.1	3 months
5. Left Perimeter - Gullys	15.0	0.5	3 months

SUMMARY AND CONCLUSIONS

This paper examined the general watershed condition of El Carrizal watershed, near Tapalpa, Jalisco, Mexico, with special reference to the road system . About 2% of the watershed area is occupied by main and secondary access roads. The area of temporary roads and skid trails is unknown. Road surfaces range from gravel and crushed rock to bare soil. Most have the latter surfacing.

Conclusions from this study are:

- El Carrizal is basically in good watershed condition at the present time;
- Roads and gullies created by roads are the main sources of sediment in the watershed; and
- Different low-cost techniques can be used to trap and stabilize eroded sediment before it can reach stream channels.

In order to sustain water quality in El Carrizal's stream in the future, more attention must be placed on designing, building, maintaining, and restoring roads to minimize erosion and consequent sediment transport to the stream channels.

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The role of herbicides in protecting long-term sustainability and water quality in forest ecosystems

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Abstract.—The use of herbicides for controlling competing vegetation during stand establishment can be beneficial to forest ecosystem sustainability and water quality by minimizing off-site soil loss. In addition, the organic residues of forestry herbicides do not adversely impair water quality.

INTRODUCTION

A critical component of inter-rotation forest management is the manipulation of successional vegetation to ensure adequate survival and growth of the next forest crop. Techniques such as mechanical site preparation, fire, and herbicides have been used to reduce competition from undesired vegetation. Herbicides have been incorporated into vegetation management programs on intensively managed forests more frequently in the past two decades. Despite considerable controversy about their environmental impacts, particularly on water quality, herbicides actually can have a positive effect on maintaining the sustainability of tree crops and protecting water quality within forest ecosystems. This paper addresses both ecosystem sustainability and water quality issues, focusing on the role of herbicides in keeping soil resources on-site.

METHODS AND MATERIALS

Standard hydrological, soil erosion, and herbicide residue methodologies were used in the conduct of this research. A detailed discussion of the specific Methods and Materials can be found in the references used for this synthesis, as well as in the full manuscript of this paper.

RESULTS AND DISCUSSION

The concept of sustainability addresses whether a site can supply sufficient water and nutrients to support successive rotations of trees. The keys to long-term sustainability are organic matter, nutrient supply, soil hydrologic function, and soil physical conditions. Tree seedlings require adequate supplies of nutrients and water to grow, and roots need a well-structured soil to develop large enough systems to support that growth (1). Vegetation management after harvesting may produce adverse effects on site characteristics which control productivity. Fire can consume much of the organic matter in slash, litter, and the mineral soil, volatilizing nitrogen and leaving nutrient-rich ash susceptible to water or wind transport off-site. Soils left bare by hot fires increase surface runoff and often develop water repellent horizons, thereby making sites erosion-prone and drier. Mechanical site preparation can redistribute organic matter, effectively removing from seedlings up to 5 times the amount of nutrients as whole-tree harvesting. Soils are often left bare and susceptible to surface runoff

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and erosion. Additional machinery passes can increase bulk density in fine textured soils, significantly reducing both rooting volume and available moisture holding capacity. Herbicides do not produce these adverse effects associated with fire and mechanical site preparation, and therefore work to minimize impacts on site productivity.

The main impact on water quality from inter-rotation vegetation management is sediment (2). Next to roads and logging skid trails, the major source of sediment comes from any ground-disturbing activity. Off-site movement of sediment from mechanical, burning, and herbicide site preparation techniques reported in the literature has ranged from 97,000 to 170 kg/ha/yr, respectively. Natural rates of sediment loss from undisturbed forest watersheds are usually <100 kg/ha/yr but in some locations can range up to 540 kg/ha/yr (2). Sediment yields during site preparation are affected by geology, soil, slopes, vegetation and litter cover, and climate. They typically are at a maximum during the first year after site preparation, and decline as vegetation recovers on the treated area (up to 4 years). The highest losses have been documented in China. Under intensive high-yield forest management in the USA, the highest documented losses (14,250 kg/ha/yr) have occurred on silt-textured soils in the upper coastal plain of Mississippi after cutting and bedding. On clay-textured soils in the Piedmont of North Carolina, sediment losses of 9730 kg/ha/yr have been reported after mechanical site preparation (blading and windrowing) to control competing vegetation. In New Zealand, maximum sediment yields the first year after clearfelling and site preparation were 6,432 kg/ha with skidder logging and burning with a 20 m riparian buffer, but were much less (611 kg/ha) with cable logging and burning with no buffer strip.

As part of a regional vegetation management environmental impact analysis, 27 watersheds in different National Forests of the Southern United States, covering all physiographic regions, were evaluated to determine the effect of vegetation management on sediment yields. Modeling of sediment yields over a 10 year period indicated that all land management activities (forestry, agriculture, grazing, etc.) would elevate natural sediment yields 5 - 487%. Forest harvesting could increase sediment production 1 - 13% above natural rates. Current post-harvest vegetation management operations on National Forest lands could increase sediment loss by another <1 - 7%. By comparison, roads on both National Forest and private lands account for sediment yield increases from 2 - 156% of the natural erosion rate.

Sediment losses resulting from inter-rotation vegetation management affect both on- and off-site environmental quality. Mechanical site preparation, which produces the largest mass of sediment loss, can result in nitrogen and phosphorus losses 21 to 30 times the normal annual rate of undisturbed forest watersheds. While these losses are low compared to agriculture-related nutrient losses, they do represent a concern for long-term forest management. For example, some forests in the southern USA now under intensive forest management were highly eroded during abusive agriculture in the late 19th and early 20th century. Due to loss of nutrient-rich A horizons, these forests remain sensitive to potential productivity declines unless augmented with fertilizers or vegetation control. Sediments transported into streams as a result of vegetation management destroy aquatic invertebrate and fish habitat, damage municipal water supplies, increase flood peaks, and detract from recreation values. Unlike organic chemicals and plant nutrients originating from fire or chemical vegetation control techniques, sediment added to stream systems does not degrade and becomes part of normal fluvial sediment transport and storage processes. The residence time of this sediment in fluvial geomorphic systems can range from decades to hundreds of years.

Research over the past two decades has documented low concentrations and short persistence of forestry herbicides in surface waters (3,4). In the Southern USA, applications of hexazinone, imazapyr, metsulfuron methyl, picloram, sulfometuron methyl, and triclopyr at rates of 0.3 to 5.6 kg/ha produced peak stream concentrations <130 mg/m^3 when buffer strips were maintained. Aerial applications to entire watersheds in both the USA and Canada have resulted in peak streamflow concentrations in the 442 - 680 mg/m^3 range. Higher concentrations (2,400 mg/m^3) have been reported in short sections of streams after accidental overflights. These peak concentrations do not persist and rapidly attenuate. Although water

quality standards do not exist for all forestry herbicides, monitoring experience clearly indicates that the rates and use patterns of these chemicals do not pose any problem for surface water quality. For instance, the suggested water quality standard for hexazinone has only been exceeded for a short time where ephemeral or perennial channels were treated. Where forestry herbicides have been detected in streamflow, the residues usually dissipate within 6-12 months, and persist in only low concentrations (<25 mg/m^3).

Forestry herbicides have been detected in shallow, surficial ground water (unconfined aquifer of soil, colluvium, or saprolite) only from broadcast applications and then only in about half the studies that monitored for them. In none of these situations were the herbicide residue concentrations of any toxicological significance. No cases exist of a bedrock aquifer being contaminated on localized or landscape scales by operational use of forestry herbicides. Transport and storage of concentrated herbicide products are the only activities with any risk for localized contamination of major aquifers.

CONCLUSIONS

From both the water quality and sustainability perspectives, herbicides have a real advantage for stand establishment and inter-rotation vegetation management. By keeping soil on site and not in streams, long-term forest sustainability is protected and water quality is not adversely affected. Considerable research and monitoring studies have shown that operational use of forestry herbicides for inter-rotation vegetation management does not create a significant risk to water quality as far as herbicide residues are concerned.

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Center for the utilization of products from forest ecosystems

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Abstract.—The Center for the Utilization of Products from Forest Ecosystem is being developed by INIFAP (Mexico), USDA FS, and Colorado State University. The goal is to develop a human and physical infrastructure allowing state-of-the-art support for the forest ecosystem utilization community. The Center will support comprehensive research and aid in educational and technical outreach programs. Economic development activities will include the total spectrum of wood (e.g., logs, lumber, veneer, etc.) and nonwood (e.g., medicinal plants, extractable chemicals, etc.) products.

Both basic and applied research will be conducted through an international industry, government, and university partnership. The execution of research projects will be driven by the formal agreements developed between the U.S. and Mexican governments. The Center will define a research agenda which recognizes the range of forest ecosystem resources and opportunities available in Mexico.

The Center plans to provide approximately 250 Mexican professionals with graduate education at the masters (M.S.) and doctoral (Ph.D.) levels. The M.S. students will be taught by foreign experts via a program developed at Colorado State University and offered in conjunction with leading Mexican universities. Ph.D. degrees will be awarded by a variety of foreign universities with recognized programs in appropriate disciplines.

Outreach through the Center includes workshops, short courses, conferences, and technology exchange to enable practicing professionals to acquire up-to-date information, exchange information in a timely fashion, involve young Mexican professionals with foreign counterparts.

An important opportunity will exist to develop the Mexican forest ecosystem products community and associate markets, and advance both U.S. and Mexican forest interests. Also, the Center will serve as a model for other countries with diverse forest ecosystems. The research, education, and outreach efforts of the Center will assist Mexico in becoming a self-sufficient, competitive participant in the international forest products community.

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INTRODUCTION

In more developed countries a large number of people directly earn their income from sustainable forest use, while the remainder of the population utilize the various products derived from forest ecosystems and realize the environmental benefits derived from responsible forest management. In developing countries, especially those with extensive and diverse forest ecosystems, the opportunities to extract a multitude of wood and nonwood forest products for social and environmental benefit are substantial. Though the evolution of technology and societies over the centuries has changed the nature of the relationship between people and forest ecosystems, it is as true now as it has ever been that a sustainable, rationally-utilized forest ecosystem can provide a vehicle to improve the quality of life for society.

Currently, Mexico stands poised to enter a new social and economic era. A progressive political leadership has come to understand that social progress will follow from economic development. To this end, Mexico is actively pursuing initiatives to stimulate domestic markets. Their task will then be to increase production and facilitate the participation of these products in global markets. However, the expanded domestic markets will also benefit countries, such as the U.S., which desire to expand foreign business activities. Due to its relatively stable political system, strengthening currency, advantageous location, and other features, Mexico is emerging as a favored venue for multinational corporations to conduct business. Furthermore, the recent adoption of the North American Free Trade Agreement (NAFTA) and the successful completion of the Uruguay round of the General Agreement on Tariffs and Trade (GATT) will not only create vehicles for economic activity in Mexico, but will signal Mexico's recognition of the numerous and collateral social, environmental, economic, political and other benefits derived from expanded international business activity.

Although the uplifting of an entire nation's economy requires the integrated efforts of many sectors, certain key sectors can have a particularly significant local and regional impact. In Mexico, the forest economy is one that can be an important instrument for large-scale social and environmental improvement, especially in rural areas throughout the country. Mexico is a country with significant human and natural resources. In particular, Mexico's large, geographically widespread, and biologically-diverse forest resource can be a perpetual source of wood and nonwood products when managed in a sustainable fashion.

Considering the substantial potential for the manufacturing of wood, chemical, medicinal and other products from Mexican forest ecosystems, neither the Mexican or foreign forest products industries are currently producing high-quality products capable of competing in domestic and global markets. Technological shortcomings starting with forest operations and continuing through the processing, manufacturing, and marketing puts forest products from Mexican forests at a distinct competitive disadvantage in the marketplace. Furthermore, the lack of quality forest products in Mexico contributes in no way to expanding markets for domestic and foreign forest products in the country.

In order to realize a competitive forest economy, a great deal of human and physical infrastructure needs to be put in place. Recently, the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP) in Mexico has initiated a comprehensive plan to create an infrastructure to perform research, assist education, and be a vehicle to promote technology transfer for forest ecosystem science, management, and utilization. This infrastructure will facilitate the development of a sustainable, environmentally-benign, internationally-competitive forest products industry. The Center for the Utilization of Products from Forest Ecosystem (CUPFE) described herein will be a basic component of this infrastructure.

OBJECTIVE

Guided by the sustainable development philosophy and cognizant of its numerous collateral social and environmental benefits, efforts are underway to develop the CUPFE, based in Chína, Campeche, Mexico. This activity is designed to develop the CUPFE over a 10-year period into a well-staffed, well-equipped, self-sufficient instrument to facilitate the development of the Mexican forest products economy. The development effort will be a partnership between SARH-INIFAP, the U.S.

Department of Agriculture, Forest Service (USDA FS) and Colorado State University (CSU). In addition, numerous industry, research, education and government facilities from Mexico and abroad will be invited to participate in CUPFE programs.

The long-term goal of the CUPFE is to realize the efficient and sustainable utilization of Mexican forests. To this end, the CUPFE will be designed to create and transfer the technical knowledge and develop the human resources necessary to facilitate the growth of markets for a wide variety of forest products and their associated industries. Market growth will have the effects of stimulating the Mexican economy through the growth of domestic industry and by foreign investment from companies wishing to produce, sell or distribute products in Mexico.

Three focal points for CUPFE activity have been identified. These are to:

- Create a human infrastructure by providing graduate education to forest products professionals to service the needs of industry, government, and education;

- Establish a physical and organizational infrastructure to conduct basic and applied research related to a wide variety of regional and national needs and to execute research in key areas related to forest products; and

- Create a system of technology exchange and outreach to facilitate the economic development of the forest products community.

It is the intent of the CUPFE to be international in scope and to serve as a model for other countries seeking a mechanism to facilitate the judicious utilization of their forest, especially tropical, ecosystems.

PROGRAMMATIC PHILOSOPHY

The institutions participating in the CUPFE share a common philosophy with respect to the relationship between forest ecosystems and their role in the social, economic, political, and environmental advancement of a country. This philosophy is based on the premise that utilizing the forest resource will lead to economic development on a large scale. Wealth generated in this fashion can be invested in the citizens of the country to impact social problems related to unemployment, education, health care, national infrastructure (water, sewage disposal, roads, etc.), and others. Resources obtained from forest ecosystem utilization will be available for the replanting, managing, and responsible stewardship of the forest resource. The access to Mexican forest resources and the associated products derived from them will have the effect of expanding markets which could be filled by foreign and domestic suppliers.

FOREST ECOSYSTEM PRODUCTS

Although Mexico possesses the world's tenth largest forest resource, it ranks only 26th in terms of forest production. Of the 20 million hectares of commercially productive forest lands, only about one-third are being managed. Furthermore, Mexico is now a net importer of all wood-based products and nearly all forest products. Domestic production of paper products has never been sufficient to satisfy Mexican needs. With the exception of composite panels, forest products from Mexico are being produced inefficiently with outdated technologies, and therefore, are too expensive to be competitive in the world markets. The lack of professionals trained in contemporary forest ecosystem utilization practices precludes the ability to implement systematic change. Furthermore, as foreign products of higher quality begin to appear in Mexican markets, the low-quality Mexican products will witness the erosion of current domestic markets. Lastly, the large number of hardwood species found in the tropics, and oaks growing in the temperate regions, present a variety of utilization challenges and commercial opportunities that currently are not being addressed.

ECONOMIC IMPACT OF CHEMICALS FROM FOREST ECOSYSTEMS

The commercial value of wood products from forest ecosystems is well known. Products, such as lumber, veneer, chips, etc., have been at the base of

forest economies throughout the world. With the advancement of chemical technologies throughout this century, a large number of nonwood products (especially extractable chemicals) have been developed from forest ecosystems. These include primary botanochemicals (substances directly extractable from plants) and secondary botanochemicals (those derived from conversion of insoluble saccharides and lignocelluloses). Primary botanochemicals include products such as naval stores (pine chemicals), tall-oil products (paper-pulping byproducts), oils for industrial uses, waxes, tannins, and rubber. Traditional secondary botanochemicals include furfural and ethanol. Potential new botanochemicals include latex- or whole-plant oils, guayule rubber, polyphenols, specialty seed oils, and such potential lignocellulose conversion products as methane, fuel alcohol, and a variety of other fermentation-produced fuels and chemical intermediates. In the U.S. today, it is estimated that approximately 2500 products (clothing, preservatives, sweeteners, paints, etc.) routinely used by people in their daily lives are derived, at least in part, from forest ecosystems.

In recent years, the price of petrochemicals has remained higher than that of similar agricultural and forestry products. As such, the latter have become more economically attractive. For about the past 15 years, various major U.S. petrochemical companies have been making substantial investments in new technologies for producing pine chemicals, guayule rubber, fuel alcohol (e.g., ethanol as an additive to gasoline) from cellulosic residues, whole-plant oils, and other botanochemicals. Clearly, the petrochemical industry has made a dramatic shift toward a renewable resource base.

Medicinal Drugs From Plants

For all of the excitement that botanochemicals have generated in the chemical industry throughout the world, the product area with the greatest potential for explosive economic growth and impact on the lives of people throughout the world is in pharmaceutical chemicals.

Plants have always had an important role in medicine and public health[4]. In developing countries, more than 80% of the population depends upon traditional plant-based medicines[5], and even in the U.S., 25% of prescription drugs are still based on phytochemicals (from only 40 species). Phytochemicals, which protect plants from the harmful effects of sunlight, are being found to have positive medicinal effects on people. In particular, these chemicals appear to be able to block the multiple processes that lead to cancer. In April 1994, researchers at Johns Hopkins Medical Institution have confirmed the cancer-preventing value of sulforaphane (a compound found in broccoli). The National Cancer Institute is so interested in phytochemicals that it has launched a multimillion-dollar project to find, isolate and study their properties. Pharmaceutical companies are also extremely interested in phytochemicals for their enormous economic potential.

In a paper by Principe[6], data are presented which are used to examine the loss of market value of plant-based chemicals due to plant extinction in the tropical regions of the world. It is estimated from available commercial data that in 1990, retail value of plant-based drugs in the U.S. was $15.5 billion. On the assumption that prescriptions in 1990 were based on 40 plant species, the average income/species was approximately $390 million. From data developed from a consensus of drug development professionals, the likelihood that any given plant will yield a marketable prescription drug is about 1 in 2000.

Of the estimated 250,000 known plant species, about 25% are projected to be extinct by the year 2050. Assuming a constant rate of extinction between 1991 and 2050, the annual loss will be 1059 species. This amounts to the loss of a market-

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able drug every two years on average. The estimated loss in the first year would be about $200 million with losses increasing by that amount yearly. This calculation presents some idea of the order of magnitude of the worth of each marketable drug developed from forest ecosystems. Furthermore, the analysis presented here put no value on the human lives that are saved and improved through the use of these drugs. It is projected that the current value of just anti-cancer drugs alone between now and 2050 would be of the order of 7 trillion dollars!

In 1980, no U.S. company admitted to conducting research on higher plants. In 1990, over 100 U.S. companies (over 220 world-wide) were involved in plant research with several clinical trials in progress[7]. One reason for the apparently sudden reversal of attitude is the commercial success of new plant-derived drugs (e.g., anti-cancer drugs, vincristine and vinblastine, derived from the rosy periwinkle). Vincristine and vinblastine had a retail value of $100 million for the Eli Lily Company in 1985. The U.S. chemical giant Merck has invested $1 million over two years in a project in Costa Rica, which has 11,000 plant species (5.7% of the world's total).

VALUE-ADDED PRODUCTS

Traditional forest utilization has focused on the maximization of wood fiber produced on an area of land. Furthermore, production of commodity items (e.g., roundwood, lumber, chips, fuelwood, etc.) has dominated the overall utilization scheme. Although commodity products still maintain a position in a comprehensive forest utilization plan, the economic and social value of other end uses and products must be recognized. Throughout the entire world-wide forest products community, ways are constantly being sought to improve the value of products. Wood products with value-added (e.g., composite structural products, paper, etc.) as well as a wide variety of nonwood products (chemicals, medicines, etc.) are integral parts of a more rational and systematic utilization scheme. More developed countries have put considerable effort into adding value to basic commodity products to maximize the income from each unit of material. For example, when a piece of dimension lumber is sold as a commodity item, it returns the producer only a few cents. However, when value is added to the same lumber by manufacture into an engineered structural system (e.g. truss, roof, bridge, etc.), the economic return is considerably greater. Analogous value-added products can be made from pulp and chemicals.

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ECONOMIC DEVELOPMENT

Fundamental to the growth and ultimate success of any new business venture in an emerging economic environment is the establishment of programs to facilitate commercial development. This is especially true for smaller, under-capitalized companies that wish to compete in technology-oriented markets. For technology-based companies, economic development programs must address the areas which most directly affect the organization's potential for success. In order to take a concept through the intricacies associated with assessing technical feasibility, product development, production, marketing, distribution, etc., a company needs access to three critical components. These are capital, expertise, and technology.

Through the efforts of the CUPFE, access to expertise will be available to the entire forest utilization community throughout Mexico. In the near future, there will be a growing number of highly-trained technical people in Mexico with expertise in the numerous areas associated with forest ecosystem utilization. Many of these people will be affiliated with the CUPFE at either the national, regional or state levels. At these facilities, professional staff will be available to liaise with clientele needing technical assistance and/or the expertise related to forest utilization. This concept is similar to the system of national technology centers currently being promoted by the Clinton Administration. Furthermore, as technical information begins to proliferate from CUPFE, and the

network of international technology transfer becomes fully implemented in Mexico, the forest ecosystem utilization community will have complete access to all available technical information.

The CUPFE will also be an instrument to facilitate nationwide industry access to technology. Through many of the outreach activities, interested parties will have access to technological developments related to their business interests. As important as access to technology and expertise is to a technically-oriented business, without the needed capital, no business venture can be developed. Although the CUPFE is not intended to be a source of capital for private commerce, the CUPFE can be an instrument to help private businesses find sources of capital and use it in the most profitable ways. For example, when government programs related to the availability of low-interest loans or small business initiatives become available, the CUPFE will be able to provide information related to such matters as application procedures, existence of technical support and potential cooperators, additional funding, and other matters.

In addition, the marketing and commercialization component of the CUPFE will be charged with keeping up-to-date information regarding how such things as tax codes and government policy can influence the corporate profitability. For example, CUPFE staff can advise companies on changes in government policy which can have an impact on business, the existence of new tax incentive programs (e.g., enterprise zones) to entice business to expand in certain areas, developments in international commercial agreements which can affect domestic and foreign business activities, and other issues affecting company profitability.

The CUPFE will be the national center focusing on utilization of products and materials from forest ecosystems. Table 1 shows the initial areas of research interest. From this table, it is clear that the three main areas correspond to the evolution of a product from raw material, to industrial conversion, concluding with the commercialization. In each of these areas, environmental considerations will be given particular attention.

TECHNICAL INTEREST OF THE CUPFE

The technical interests of the CUPFE are illustrated by category in Table 1. This table shows the cycle of forest products development from the forest to the commercialization. These areas will constitute the nucleus about which the Center will grow.

More specifically, five projects have been identified as those which will be executed in the initial phase of CUPFE efforts. These are:

- Raw material acquisition
- Mechanical conversion and quality control and assurance (especially tropical species and oaks)
- Drying of mixed species (especially tropical species and oaks)

Table 1. Areas of research interest at the CUPFE.

Raw Material Acquisition	Industrial Processes	Commercialization
Harvesting Systems, Equipment and Processes	Primary Materials	Marketing
Roads and Transportation Equipment	Wood Product Development	Economics
	Nonwood Product Development	Int'l Trade Agreements
	Wood Machining and Processing Equipment	Feasibility Analyses

- Utilization of nontraditional species for wood and nonwood products

- Commercialization of products (focusing on economic development)

These topics will serve as the nucleus about which the CUPFE will be established. Of course, as the CUPFE evolves, experience will be gained, new initiatives will be created which reflect industry needs, and the human and physical infrastructure and the number of research areas of the CUPFE will be increased in proportion to the perceived needs in each technical area.

THE PROGRAM

A detailed program is described which is designed to serve the interests of a broad clientele within the Mexican forest products community. This program has three basic components: research, educational assistance, and outreach. A facility will be established by INIFAP near the town of Chína, Campeche, to be the national branch of the CUPFE. Here, research will be conducted on basic subjects and applied topics of a more national scope. Also, educational activities involving teaching and research will be performed in Chína. State-of-the-art forest products related technology and equipment will be placed in CUPFE laboratories. A cooperative program of basic and applied research will be continued between INIFAP and foreign partners. A program of training and technical information dissemination will be available to practicing professionals within the Mexican forest products community. This outreach effort will be fundamental to a more broad economic development mission of the CUPFE.

RESEARCH

The topics that will be studied in the initial development phase of the CUPFE will be those that fit into one of the five areas described above.

In the early years of the CUPFE, there will be a modest infrastructure with few highly-trained research professionals. Therefore, only a few research projects will be initiated, and these will be executed with the assistance of outside laboratories and professionals. As time passes and the human and physical infrastructure grow and develop, the number and dimension of the CUPFE's research projects will proportionately increase. To initiate the research program of the CUPFE, five projects will be started which reflect INIFAP's strategic interests. In the following paragraphs, five projects are described with a brief project justification, description of the activity, and expected benefits.

Raw Material Acquisition

Currently, the acquisition of raw material from the forest is accomplished in Mexico in a most inefficient and ineffective fashion. A great deal of the total product cost is incurred in the forest, and logs are brought to the mills without serious regard for maintaining log quality or environmental integrity. The proposed project will identify current methods of forest operations being used throughout the world and their relation to the unique features of Mexican forests (tropical and temperate). In addition, efforts will be directed towards adapting contemporary technology and/or developing new technology, sensitive to environmental impacts and appropriate for the Mexican forests. The successful execution of this project will result in a more optimal process for material acquisition. Furthermore, more rational harvesting will minimize damage to logs, and therefore the products from which they are made, and reduce the cost of harvesting with the result of improving profitability. Furthermore, improved forest operations will have positive environmental impacts by minimizing the effect of harvesting on soil and forest fauna and flora.

Mechanical Conversion and Quality Control and Assurance

Basic to the profitable manufacture of lumber is the ability to produce the maximum amount of straight products with a minimum of strength reducing characteristics, made to tight tolerances in size, and available to the customer at a moisture content compatible with end use. Currently, Mexican lumber manufacturer's are not capable of producing products in a fashion that is both profitable to the producer and of a quality to satisfy

domestic and foreign customers. This project will aim at identifying available technology useful in improving the yield and quality of Mexican lumber. In addition, professionals involved with economic development will assist lumber producers in finding methods to finance technological improvements necessary to be more competitive. The successful completion of this project will result in Mexican producers improving their products, becoming more market competitive, increasing their potential for profitability.

Utilization of Non-Traditional Species

One of the most vexing forest utilization problems faced throughout the world relates to the profitable utilization of diverse species. In Mexico, hundreds of hardwood species can be found in close proximity in the tropical forests, as well as over thirty oak species in the temperate zone. At the moment, only a small number of species are being used in a profitable fashion. The proposed project will be directed at identifying new and potentially profitable uses for species presently being overlooked for utilization, and identifying substitute species for products currently being made from traditional species. The successful conclusion of this product will have the effect of reducing harvesting pressure on certain well-used species with a positive impact on biodiversity. Furthermore, new business opportunities will result from the availability of more species from which more and diverse products can be made.

Drying of Mixed Species

It is well known that a successful drying schedule for one species may not be optimal for another species. As such, inefficiencies resulting from the drying of mixed species can have a negative impact on efficiency and profitability. In this project, two goals will be sought. The first goal will involve attempting to optimize the drying charge (not necessarily every individual species). The second goal of this project will be to optimize drying of multiple products as a function of the end use of the product. Successful completion of this project will manifest itself as a means for greater profitability and product diversity.

Product Commercialization

It is clear that if product commercialization is not successful, all technological innovations are useless. Therefore, it is the intent of this project to assist the forest products industry by providing information relevant to getting potentially profitable products into the market and finding the means to make production possible. Studies will be executed which relate to the feasibility and business implications of new product development. The potential benefits of these projects can be substantial. Helping industry distinguish between product lines with high and low probabilities of success can help avoid commercial blunders. Furthermore, in a rapidly changing world of international trade agreements, this project will help industry to be aware of changes in law and new opportunities to market their products.

EDUCATIONAL ASSISTANCE

To participate in the increasingly competitive international forest products market, it is vital that a country have a cadre of highly-educated professionals capable of relating to the numerous issues associated with sustaining the resource, raw material acquisition and conversion, product development, utilization, marketing, etc. Therefore, a comprehensive program of graduate education in the area of forest ecosystem utilization is being planned.

In the course of a decade, approximately 240 Mexican professionals trained at the B.S. level in forestry, forest products, or a related field will receive graduate education leading to the M.S. and/or Ph.D. degrees in an area germane to forest ecosystem utilization. Of these 240 students, about 180 will be in the M.S. program, while 60 of the best students will pursue a Ph.D. The M.S. degrees will be awarded by a Mexican University in conjunction with CSU. Ph.D. degrees will be obtained through a foreign university.

Structure of the M.S. Program - Currently, there are few Mexican forest products professionals with graduate-level degrees. In fact, a critical intellectual mass in forest ecosystem utilization does not exist. Therefore, the education of forest utilization professionals will be a major component of the

CUPFE. To initiate this program, only M.S. students will be taught. As these students finish their M.S. programs, some will begin professional careers while others will pursue Ph.D. degrees abroad.

The unique M.S. program in forest ecosystem utilization was developed at CSU. This educational package will be delivered as a cooperative effort between CSU, several Mexican and foreign universities and research institutions. It is important to note that all degrees will be awarded by Mexican universities in cooperation with CSU. Students will take courses at Mexican universities in subjects ancillary to forest utilization (i.e. mathematics, engineering, business, economics). In addition, foreign experts will come to Mexico to teach courses idiosyncratic to forest utilization (i.e., forest operations, wood drying, machining of wood, etc.).

Structure of the Ph.D. Program - Whereas the M.S. program focuses on applied research, the Ph.D. degree demands research at a more fundamental level. Since it is neither practical nor expedient for Mexican industry to perform basic research, each Ph.D. student will conduct his/her studies at a foreign university.

OUTREACH

Once research or other technical information is available, it is imperative that this information become available to the appropriate user groups. With the purpose of disseminating technical information to practicing professionals, a significant outreach program to the Mexican forest ecosystem utilization community will be initiated. This program will involve the following components:

- *Workshops*–Annual workshops, designed to identify current technical needs of the industry, will be presented. These 3-5 day workshops will bring technical people together in a forum in which common technical problems can be identified. Technology can be shared, and more importantly, timely issues can be identified which could be the subject of future short courses.

- *Short Courses*–It is anticipated that approximately 2-3 short courses/year will be offered throughout the project duration. These courses will be of a 3-5 day duration and will be aimed at providing technical information to currently active professionals directly or indirectly (e.g., architects, builders, engineers) related to forest products utilization. The subject matter of these short courses could vary from year-to-year. However, the subjects covered will be dependent on conclusions drawn from workshops and consultation pertinent advisors.

- *Technology Exchange*–A great deal of technical information currently exists that could be of great value to the Mexican forest ecosystem utilization community. Furthermore, a great deal more information will become available as student and government research comes to fruition. It is imperative that this information be made available to practicing forest products professionals in the most expedient fashion possible. To this end, several technology exchange vehicles (in addition to those stated above) will be implemented. These vehicles will include:

    - A series of technical reports will be published in Spanish and English which describe research performed by government agencies and students in graduate programs. In many cases, these reports will be the student theses or dissertations or final project reports from government research laboratories. This vehicle has the advantage of providing information on a wide variety of subjects in one easily accessed location. Furthermore, this information will become available shortly after completion of the work, as opposed to refereed journal articles which are often capsulated accounts of the work and require a considerable amount of time to publish. The INIFAP will publish these reports and be responsible for distribution to the forest ecosystem utilization community.

- It will be required of all researchers (including students) associated with this project to publish refereed journal articles describing their research activities. The peer review process will provide the necessary credibility required for Mexican researchers to stand equal to their foreign counterparts. Also, journals with international distribution will be accessible to researchers throughout the world, and establish Mexico's leadership position among the major forest products countries.

- It is important for professionals with related interests to meet regularly to exchange technical information. A process to develop an annual conference of the Mexican forest products community will be initiated to provide interested individuals a venue to exchange technical information and discuss issues of mutual concern.

- Once Mexican research results and technological developments begin to appear, it will be important to disseminate this information to the international forest products community. To this end, funding will be sought to send 10 professionals/year to international conferences {e.g. Union of International Forest Research Organizations, Forest Products Society, etc.} to present research results. It is vital that Mexican professionals attend meetings with foreign colleagues, and gain credibility by making technical presentations at these venues.

- To enhance credibility of Mexican research and provide market exposure for domestic forest products, three international conferences (on subjects to be determined by the directors in consultation with pertinent advisors) will be planned for the early 21st century and hosted in Mexico. Also, conferences of this type (with associated product exhibitions) will have important implications for product promotion to international markets.

- The FPS, which is North America's preeminent forest products technology exchange vehicle, has enthusiastically endorsed the program and desires to be involved (see Appendix IV for letter of endorsement). Although all possible mechanisms for FPS involvement have not yet been identified, two ideas have been discussed. First, once a critical mass of forest products professionals has been created, the FPS will initiate the process of forming a Mexican Section. The existence of this section will substantially expedite technology exchange within Mexico and throughout North America and many parts of the world. Second, FPS has agreed to cosponsor workshops, short courses, and conferences in Mexico. The FPS has proved to be an important means of advertising and promoting such events to international audiences. The FPS Executive Director has agreed to explore additional avenues of FPS involvement in this project.

- The Society of Wood Science and Technology (SWST) (the forest products professional society) has also enthusiastically endorsed this program and has expressed interest in participation. The SWST is considering several possible vehicles for involvement in this program.

SUMMARY

Planning is underway for a Center for the Utilization of Products from Forest Ecosystems in Mexico. This Center is designed to be an instrument in the development of the Mexican forest products community. Fundamental to efforts of the CUPFE is the sustainability of a profitable and economically vital forest products economy. Research, educational assistance, and technical outreach will constitute the modes of activity. Throughout all of the CUPFE's proposed activities, concerns for environmental impacts will be foremost.

Creating wildlife trees in managed forests using decay fungi

Catherine A. Parks[1], Evelyn L. Bull[1], and Gregory M. Filip[2]

Abstract.—A method to provide internal wood-decay conditions needed by cavity excavators is being tested in six stands in northeastern Oregon. Preliminary results find that after five years 50 percent of artificially inoculated trees in one stand are being used by cavity nesters. All inoculated trees remain alive with viable crowns. Because of the biology and natural abundance of airborne spores of the decay fungi used, there is no likelihood of spread into non-target trees. These preliminary results suggest that inoculation may be a viable tool to create suitable habitat for snag-dependent wildlife in coniferous forests in greater abundance or at younger ages than would naturally occur.

INTRODUCTION

Several investigators have reported the relation between cavity nest sites of birds and internal decay of trees (Shigo and Kilham 1968, Conner et al. 1976, McClelland 1977, Miller et al. 1979). Managing for cavity-dependent wildlife is a major issue for State and National Forest resource managers who have difficulty maintaining snags (dead standing trees), which are often harvested for fiber and firewood or felled for safety. Managers of public lands in the United States are now required to retain habitat for snag-dependent wildlife in timber sales or other intensive management activities. Current technology does not supply the tools needed if the laws are changed to mandate that land managers not only retain but establish this critical habitat. Several methods for killing trees to produce snags for cavity nesting birds have been tested (Conner et al. 1981, McComb and Rumsey 1983, Bull and Partridge 1986). Observations from these studies suggest that trees killed by herbicides and girdling fall sooner than trees killed by natural causes and are rarely used by cavity nesters. Bull and Partridge (1986) report that trees that are limbed and topped by an explosive charge are most frequently used by nesting woodpeckers and stand the longest. This technique is the method used most in the Pacific Northwest by forest managers actively recruiting snags by killing trees. Unfortunately, this technique is expensive, requires highly skilled personnel, and produces unpredictable results.

Although dead trees are the most common nest sites for cavity dwellers, live trees may also accommodate nesters if the boles contain decayed wood. Affeltranger (1971) and Conner et al. (1983) suggest that live trees might be made suitable for cavity excavation by inoculating them with stem-decay fungi. Conner et al. (1983) report an 80 percent success rate when inoculating living oaks.

Cavity-dependent wildlife is a vital part of sustainable forest ecosystems. We believe that, if successful, inoculation could be used to create suitable habitat for cavity-dependent wildlife in coniferous forest in greater abundance or at younger ages than would normally occur.

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BACKGROUND

In 1988 we initiated a research project to identify decay fungi associated with woodpecker cavities in live western larch trees (*Larix occidentalis* Nutt.). We surveyed 20 live western larch that had active cavity dweller nest sites. Isolations were made from wood collected around the nesting area. Using the fungal decay organisms isolated from the survey, we have initiated an artificial inoculation trial. The study goal is to determine the capacity to cause internal decay of living western larch by artificial inoculation, and to monitor inoculated trees for woodpecker excavation. We inoculated 10 trees in each of six study areas in northeastern Oregon.

Four years later, in 1992, we randomly selected two trees to fell and estimate the progression of the fungus. Both trees had large areas of internal decay that were obviously associated with the artificial inoculations. Re-isolation substantiated that the decay was caused by the inoculated fungi.

SUCCESS TO DATE

Five and one half years later, in 1994, we found that one study area had cavities in five of the ten inoculated trees. The largest cavity at the site was approximately 11 inches by 7 inches. All inoculated trees remained live with viable crowns.

We are encouraged by the results of the larch inoculations. Western larch is thought to be very decay resistant and it is likely that other tree species would decay at a faster rate. However, with all tree species there is little chance of any type of spread to neighboring trees from inoculation procedures. Conversely, creating the proper conditions in an individual tree for fungal development is to be the challenge of this procedure. These fungi are very common in all forests of the Pacific Northwest, the airborne spores are ubiquitous organisms.

FUTURE DEVELOPMENT PROJECTS

To continue with the progression of studies in this research area, we have now initiated field inoculations of select fungi in other tree species. As of October of 1993, four National Forests in Oregon inoculated over 600 Douglas-fir (*Psuedotsuga menziesii*). Half of those trees were inoculated with Fomitopsis cajanderi Karst.; half with *Phellinus pini* (Thore ex Fr.) Pilat. Records were made of tree location, diameter, and the identity of the fungal species introduced. Inoculations were made as follows:

Inoculum consisted of birch (*Betula* spp.) dowel sections (8 x 2.5 cm), thoroughly colonized by one of fungi. Inoculations were made at 7 m above ground. This height was chosen because it is within the nest height of most woodpeckers (Thomas et al. 1979). Each tree received one inocula. Inoculum was inserted into a drilled hole followed by a partially inserted 10-cm-long hollow plastic tube, 2.5 cm in diameter. Tubes are placed in holes to keep resin out and to prevent tree growth from sealing the opening. Inoculations are made in fall when resin flow is minimal (to reduce wound sealing) and moisture conditions are increased from the summer (to reduce inoculum drying).

Additional research is being conducted to evaluate the feasibility of inoculating live trees with rifle- and shotgun-delivered inoculum. Earlier work by Baker, Daniels and Parks (in press) found that fungi could survive in dowels that were encapsulated into bullets and shot into trees with a .45-70 rifle. On going work is designed to determine if firearm delivered inoculum can initiate a decay column.

Inoculated trees will be checked every third year for evidence of woodpecker use (i.e., presence of nest cavities, chips, or foraging activity in the bark or wood), decline or mortality, and evidence of fungal fruiting structures.

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How wildlife concerns were addressed within the Sacramento River Ecosystem Management Area

Danney Salas and Tim Meyer[1]

Abstract.—The Sacramento River Ecosystem Area in the Lincoln National Forest encompasses several life zones and approximately 47,000 acres of diverse landscape ranging from mixed conifer forest to desert shrub. The general desired condition for this area is a resilient, sustainable ecosystem that integrates social values and needs into the landscape. Five descriptive parameters were used to define reference, existing, and desired conditions: vegetation type; vegetation structural stage; range condition; stream condition; and social climate. Critical habitat components were identified for four species (Mexican spotted owl, northern goshawk, rocky mountain elk, and mule deer) and tied to a vegetation type and/or structure. The vegetation parameters were then analyzed for their effects on each of the four species.

CURRENT CONDITION

This ecosystem area encompasses several life zones and approximately 47,000 acres of diverse landscape ranging from mixed conifer forest to desert shrub. Elevations range from 9,700 feet to 6,600 feet.

Many different wildlife species are found in the area, including three threatened or endangered species. The upper watershed serves as habitat for bald eagle, goshawk, Sacramento mountain salamander, flammulated owl, Mexican spotted owl, and other unique species. The area also serves as summer and winter habitat for a wide variety of species from big game animals, such as deer, elk, bear, and turkey to many of the neotropical migrant birds.

The watershed contains one of the few free-flowing streams within the Tularosa Basin. Much of the riparian is typified by blue grass bottoms, lack of woody vegetation and incised stream channels with lacking overhanging stream banks. The watershed provides the domestic water supply for the community of Oro Grande.

Management on four range allotments directly effect this watershed. The existing transportation systems services the Timberon community, a major forest access point for visitors from El Paso, the fire escape route for the community of Sunspot, the one 4-H camp, and the transportation of forest products. Recreational use is "dispersed" with common activities being camping, wildlife viewing, hunting, fishing, and picnicking.

Forest conditions are relatively young and homogeneous. Stands are often overstocked exhibiting mistletoe, various insects and diseases. Much of the aspen component is presently mature and being lost through forest succession. The ponderosa pine component exhibits forest health problems and seral progression towards fir species. The pinyon and juniper is increasing in density on the uplands as well as in deeper soiled grassland bottoms.

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DESIRED CONDITION

The desired future condition of the Sac EM Area (Sacramento Ecosystem Management Area) is to attain a resilient, sustainable ecosystem which has integrated social values and needs into the landscape and which exemplifies ecologically-based multiple-use management.

To help describe existing and desired conditions five broad parameters were used: 1) Amount of major vegetation types; 2) Vegetation Structural Stage distribution within each vegetation type; 3) Range condition, 4) Stream classification; and 5) Social climate.

The following data is a breakdown of the amount of each vegetation type, both existing and desired conditions as the percent of the area in National Forest Administration. State and private lands are not included in desired conditions at this time. They will be added when and if agreements are established with the state or private land owner.

Vegetation type	Existing	Desired
Aspen	1%	3%
Mixed conifer	56%	50%
Ponderosa Pine	8%	15%
Pinyon/juniper	26%	23%
Meadow/grass	1%	1%
Browse	8%	8%

Currently 160 acres of aspen type exists. Another 1,200 acres exists where aspen is a significant, though not the dominant, component of the stand. In the absence of disturbance, such as fire, natural succession will usually replace aspen stands with conifers, like white fir and spruce. Historically fires are assumed to have occurred more frequently. Following this assumption the desired condition is to increase the amount of aspen to 3 percent of the area, with an even distribution of vegetation structural stage (VSS) closer to the amount found historically.

The mixed conifer forest type includes stands of Douglas-fir, white fir, Engelmann spruce, and Southwestern white pine. There are estimated 18,140 acres. There are, however, some areas that are currently classified as mixed conifer, but they are composed of mostly oak and other brush. These areas were burned and regenerated to oak brush. The conifers are slowly reoccupying these sites. The desired condition is to sustain the mixed conifer for suitable owl nesting and roosting habitat and to provide for other ecosystem functions. The desired VSS condition is skewed to the larger classes with even distribution of densities within those larger classes and multi-storied. The desired condition shows a reduction in mixed conifer (17,328 acres). This reflects the desire to have more pure aspen stands and pure pine stands, most of which are currently mixed conifer.

In the past, ponderosa pine occupied many of the canyon bottoms in stands that are now classified as pinyon/juniper (P/J). On the upper elevational end of the P/J range, P/J is becoming more prevalent as a component in ponderosa pine stands. Many pine stands are in various stages of converting to stands of mixed conifer or pinyon/juniper. The desired condition is to keep ponderosa pine as the primary tree species in these stands and/or to have pure stands of pine similar to historic levels. To sustain the ponderosa pine for suitable goshawk habitat and to provide for other ecosystem functions, VSS conditions skewed to the larger classes with even distribution of densities and with more single storied are desired. There is a increase in ponderosa pine acres from existing conditions.

The old photographs of the P/J area show open habitats. The desired condition is to maintain some P/J in the ponderosa pine stringers for its value as wildlife habitat and diversity. To sustain the P/J in suitable habitat for wintering ungulates and to provide for other ecosystem functions, VSS conditions slightly skewed to VSS class 3 (young forest) and skewed to the open canopy density is desirable. The desired condition shows a reduction in the number of acres in P/J from existing conditions.

The desired acreage condition for meadows is the same as existing conditions. There are many meadows, however, where trees (both mixed conifers and P/J) are encroaching and beginning to take over. The desired condition is to maintain these areas as meadows.

The desired condition for browse acreage is to maintain existing acres of browse into the foreseeable future. Browse plant species would also be present in all other vegetation types, providing

forage and cover for wildlife. The amounts of this browse will vary as tree densities vary in other vegetation types.

Desired range condition is to have most full capacity lands in mid to high seral conditions.

Desired Stream type/condition is to have meandering streams where possible and have the riparian in good condition including woody species.

There are several parts to social climate (*Special uses, Grazing, State and private lands, Water supply, Recreation, Access, Products/local economy, Aesthetics/ remoteness/wildness*, and *Wildlife*).

Existing conditions include observatories, military installations, utility lines, a water transmission line, a 4-H Camp, outfitter/guides, grazing permits, approximately 14,473 of state and private lands, and the Oro Grande water supply.

The area also has some heavy dispersed camping use, sight-seeing, hiking, biking, snowmobiling and picnicking. Areas of heavy camping use are showing signs of sanitation problems and damage to vegetation that may lead to other resource damage. There are no developed recreation sites on the National Forest portion of the EM area. The area is part of a scenic byway and is losing it's fall colors. Even though the unit has very good access, the relative remoteness of the area, the large forested areas and steep terrain provides a sense of wildness that many people seem to enjoy. There are many opportunities for hunting, and for viewing both big game and non-game animals.

Approximately 20 miles of trails and 73 miles of roads exist on the National Forest. The Sacramento River Road is immediately adjacent to the river in several spots. In these locations, runoff from the road is degrading water quality. Sight distance and condition of the surface of FR 537 limit vehicle speed. The road is used year-around by residents, utility companies, mail carriers, etc., and seasonally by tourists and school buses.

The area has some production of cattle, and limited quantities of fuelwood and other timber products. There are also three species in the area that are currently protected by the Endangered Species Act.

The **desired** condition is to continue these uses, but improving the administration of the permits. Applications for new special uses, new or changes to allotment management plans should be approved when they are consistent with the desired conditions for the other four parameters. Water quality standards should be maintained in the river and ensure that water management is consistent with other desired conditions. Partnerships should be developed with other landowners to achieve mutual objectives. As opportunities arise, ownership should be consolidated where feasible and in the best interests of the government and the public. What occurs on State and private land will have some influence on what can be accomplished on public lands.

The **desired** conditions include managing recreation uses to minimize resource damage, and to "harden" some popular sites to allow higher use levels without damaging the environment. All activities should be done in a way that will maintain the "wild" feeling for those passing through or using the area. The amount of aspen will be increased in the landscape for more fall color and visual variety. Habitats should be provided for all species, especially in the riparian areas. Opportunities should be improved for safe viewing and hunting of wildlife.

Desired conditions includes improving road and trail maintenance to minimize resource damage, including relocation where necessary. It ensures that roads and trails are safe for appropriate uses.

Desired condition is for the Sac EM area to contribute toward sustaining the local economy by providing some of the raw material needs of local industries. In some cases, the commodity production will merely be the result of achieving some other ecological desired condition. In other cases, commodity production may be the primary goal, but would be done subject to the desired conditions for the whole EM area and comply with the Endangered Species Act.

ADDRESSING WILDLIFE CONCERNS

There are 383 possible wildlife species that may occur within the area. A healthy ecosystem is needed to provide for all this diversity. The assumption made in the Sac EM area in developing the desired condition is that if all the vegetative parts are present, then the wildlife will also be present. Public concern is higher for some species

than for others. Four of these high profile species will be used as examples as to how wildlife habitats were considered within the Sac EM Area. The four species are Mexican Spotted Owl (*Strix occidentalis lucida*), northern goshawk (*Accipiter gentilis*), Rocky mountain elk (*Cervus Canadensis*), and Mule deer (*Odocoileus hemionus*).

Mexican Spotted Owl (MSO)

Nesting and roosting habitat are considered the critical habitat components when addressing MSO concerns. Foraging and dispersal habitat are of lesser concern and are provided when other ecosystem functions are addressed. Suitable MSO habitat is dense forest with at least 60% canopy cover and multiple canopy layers in the mixed conifer and ponderosa pine types. In ponderosa pine types, an oak understory usually provides the multiple-layered canopy effect. According to The Final Rule to List the Mexican Spotted Owl as a Threatened Species in the Federal Register Vol. 58. No.49., ponderosa pine and pinyon/juniper are not suitable habitat for nesting and roosting unless an owl is actually using the area for nesting or roosting.

Preliminary prey base data being taken on the Lincoln National Forest suggests that the owl utilizes three main food sources: wood rats, deer mice and voles. Foraging and dispersal habitat occur throughout several forest types from pinyon/juniper to spruce/fir.

All existing nesting and roosting habitat within the Sac EM Area is within the mixed conifer vegetation type. Because of this, desired condition for MSO habitat within the Sac EM Area will be addressed through the parameters of: the amount of mixed conifer type and the vegetation structural stages (VSS) within the mixed conifer. Suitable habitat for nesting and roosting fall within VSS 3 (young forest) through over-mature forest, and moderate to dense canopy closures. There is some indication that the mature and over-mature forests provide higher quality habitat than the younger classes. There is also the suggestion that dense canopies are of higher quality than more open canopies. The desired condition is to sustain as much suitable habitat as possible. There are currently 11,756 acres of suitable habitat and will be 10,064 acres of suitable when desired conditions for the Sac EM are met.

Because fires were assumed to be more frequent historically, it is assumed that the amount of mixed conifer habitat existing is more and that the density is higher than what was historic. The Sac EM desired condition reflects this assumption and shows a reduction in mixed conifer habitat while reflecting an increase in most other forest types. It is felt that this reduction in habitat will not reduce the survival of the Mexican spotted owl in the Sac EM area or the population of the Sacramento Mountains.

To address concerns, a desired condition for suitable, sustainable Mexican spotted owl habitat alone, within the existing mixed conifer was evaluated. Increases in habitat would occur from present condition and from the EM desired condition. The difference between "owls alone" and "EM" desired conditions was minimal for owls, but showed losses for the other three species examined.

Northern Goshawk

Ponderosa pine and mixed-conifer forest types with a variety of age and size classes are suitable goshawk habitat. The Region 3 Goshawk Scientific Committee recommendations call for Vegetation Structural Stage (VSS) distribution of 10 percent grass/forb/shrub (VSS1), 10 percent seedling sapling forest (VSS2), 20 percent young forest (VSS3), 20 percent mid-aged forest (VSS4), 20 percent mature forest (VSS5), and 20 percent old forest (VSS6) for foraging and family care areas. Nesting habitat was to be in VSS 5 or 6. Snags, downed logs, woody debris, and openings with reserve trees are important components of goshawk habitat.

The existing nesting conditions for goshawk in the Sac EM area occur in small isolated areas. Foraging and family caring habitat is present throughout but the age and dense conditions of the forest are not conducive to high quality goshawk habitat. The desired condition is to keep as much sustainable, suitable habitat as possible within the ponderosa pine type. The mixed conifer type will be managed for owls but will provide some suit-

able habitat for goshawks. There are currently 1,995 acres of suitable habitat and will be 3,020 acres of suitable when desired conditions are met.

Because fires were assumed to be more frequent historically it is assumed that the amount of ponderosa pine habitat existing is less and that the density is higher than what was historic there. The desired condition reflects this assumption and shows an increase in ponderosa pine habitat. It is felt that this increase in habitat will enhance the habitat of the goshawk in the Sac EM area and the population of the Sacramento Mountains.

To address concerns, a desired condition for suitable, sustainable goshawk habitat alone, within the existing ponderosa pine, was evaluated. The mixed conifer was not included because the owl, as a federally protected species, would take priority. Increases in habitat would occur from present condition but the EM desired condition would show even more habitat. The desired conditions for "goshawk alone" showed less habitat for goshawks than the EM desired conditions because other resources concerns would increase the amount of pine habitat.

Elk

Elk use the Sac EM area year around with spring, summer and fall being the most critical. The area is also used for elk calving. The New Mexico Department recommends that the forage to cover ratio for elk be at 60 percent forage to 40 percent cover.

The existing forage to cover ratio is skewed to the cover side. The desired condition is to increase the amount of foraging habitat within the spring, summer and fall ranges. This falls within the mixed conifer and ponderosa pine types. The lower elevations will be managed for mule deer winter habitat, but will provide some suitable habitat for elk. The forage to cover ratio is currently 47/53 and will be 46/54 when desired conditions are met.

Because fires were assumed to be more frequent historically it is assumed that the amount of open mixed conifer and ponderosa pine habitat existing is less and that the density is higher than what was historic. The desired condition reflects this assumption and shows a decrease in open canopy habitat because of other resource concerns.

To address elk concerns, a desired condition of 60/40 forage to cover ratio within the existing mixed conifer and pine type was evaluated. Increases in habitat would occur from present condition and from the EM desired condition. The difference between "elk alone" and "EM" desired conditions was a decrease in elk habitat because of habitat concerns for owls and goshawks.

Mule Deer

Deer use the Sac EM area year around with winter being the most critical. The area is also used for deer fawning. The New Mexico Department recommends that the forage to cover ratio for deer be at 60 percent forage to 30 percent hiding cover and 10 percent thermal cover.

The existing forage to cover ratio is skewed to the forage side in the winter range. The desired condition is to increase the hiding and thermal cover habitats within the winter range. This falls within the pinyon/juniper and browse types. The higher elevations will be managed for elk summer habitat but will provide suitable habitat for deer. The quality of the forage within the foraging areas is currently low. The desired condition is to increase this quality on existing foraging areas. The forage to hiding to thermal cover ratio is currently 83/9/8 and will be 82/11/7 when desired conditions are met.

To address deer concerns, a desired condition of 60/30/10 forage to hiding to thermal cover ratio within the existing P/J and browse types was evaluated. Increases in cover habitat would occur from present condition and from the EM desired condition. The difference between "deer alone" and "EM" desired conditions was very substantial. This indicates a need to re-evaluate the desired conditions on deer winter range and the reliability of our data.

Preliminary inventory of the birds of the Tapalpa Region

Constantino Orduña Trejo[1] **and Alvin L. Medina**[2]

Abstract.—Birds have a potential uses as song birds or beauty, pets and some for human consumption. The objective of this study was to inventory the birds of the Tapalpa, Jalisco region and relate them to different major habitats. The techniques used were: observation using binoculars, collections using mist nets and liberation of birds thereafter. Samples and transects were placed in different vegetation conditions. Eighty species have been recorded within 22 families, with 82% of them found in forest vegetation and 18% found in agricultural areas. The diversity of birds in the forest is a direct function of the habitat conditions and the different forms of silviculture. There are birds which are found only under a given condition of the watershed, such as: *Aegolius acadicus*, *Dendroica graciao* and *Certhia americana*, which suggests they are restricted species and/or could be indicator species of forest activities.

INTRODUCTION

Wildlife inventories as a form of information for management of terrestrial vertebrate habitats and for environmental impact studies that are generated by construction activities, are important for various reasons (Franzreb 1977), some of which include:

- to identify species with environmental valor as species sensitive to adverse changes;
- to better our understanding of the ecosystems of the region, country and global;
- the "general law of ecological equilibrium and the protection of the environment" (SUDUE 1988) requires information for manifests of environmental impacts;
- the forestry laws in their various articles points out the necessity to characterize natural conditions and wildlife in particular.

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So important are birds that in the USA the conservation of neotropical birds is a program of major interest and support, although there are few biologists who clearly recognize how to apply conservation biology to the species (Niles 1992). Birds, like other groups of wildlife species, have an ecological value beyond the uses for human consumption or used as song birds, beauty, or pets. Some species are specialists of certain habitats, requiring such specific environmental conditions that it is not possible for then to survive elsewhere in other habitats (Emlen 1973). This class of species or individual species has a great diagnostic value of quality of habitats, which can be changed by various forest or watershed management activities.

For the most part, bird studies and inventories in the region of southwest Mexico are scarce, with the primary sources of information being that of field guides (Peterson and Chalif 1973; Blake 1953; Robbins et al. 1966; and National Geographic Society (1989). Other studies include list of species for selected areas: (Friedmann et al. 1950; Miller et al. 1957; American Ornithological Union 1957; Davis 1972; y Edwards 1972). The objective of this study was to inventory the birds of the Tapalpa, Jalisco region and relate in simple fashion bird groups of two major habitats, forests and agricul-

tural areas, that are found in the watershed. Secondary objectives of importance were to contribute to the GIS data base (Baker et al. 1995) that is presently being developed as part of the 'restoration of riparian ecosystems' studies underway (Medina et al. 1995); and to establish a reference point of population abundance, species diversity, and distribution of birds of the country.

STUDY AREA

Chávez-Huerta et al. (1995) describe the study area as follows. El Carrizal is a small (1,284 ha) pine forested watershed located 6 km southwest of the town of Tapalpa, Jalisco, Mexico, in the Sierra de Tapalpa (Figure 1). Elevations range from about 2,010 m at the junction of the stream (El Carrizal) and a 18 million m^3 storage reservoir (El Nogal), and 2,420 meters at the highest point. The climate is temperate and subhumid Garcia (1981). Mean annual rainfall is 901 mm and ranges from 548 mm to 1,549 mm, with 79% of the annual precipitation (717 mm) occurring between June and October (Benavides-Solorio, 1995). Rainfall during the drought season (February - April) averages about 11 mm/month. The major soil units are (Gómez-Tagle-Rojas y Chávez-Huerta, 1986): humic Andosols, chromic Cambisols and Luvisols, eutric Regosols and Litosols.

The dominant vegetation is comprised of mixed stands of pine (*Pinus michoacana* Martínez, *P. oocarpa* Schiede, *P. leiophylla Schl.* et Cham., *P. douglasiana* Martínez and *P. pseudostrobus* Lindl.), with occasional stands of pine-oak *(Pinus/Quercus)* complexes *(Benavides-Solorio, 1987)*. The better stands of pine are located from mid-slope to the ridge tops. The mid-story of stands in the middle slope zone is characterized by such species as *Crataegus* and *Quercus*, which seem to extend over the watershed as a result of opening the site and timber harvest activities. The lower slopes are an assemblage of many woody species of trees, shrubs and vines. Some of the more common plants include species of *Arbutus*, *Alnus*, *Ilex*, *Persea*, and *Prunus* (Madrigal-Sánchez et al., 1995).

Chávez-Huerta et al. (1995) describe the historical and current major activities within the watershed. These include livestock grazing and timber harvest. Apparently, livestock have grazed the watershed since the Tapalpa area was settled in mid 1600's. Archeological evidence of early settle-

Figure 1. The study area is located south of Guadalajara, in the Sierra de Tapalpa, State of Jalisco.

ments within the watershed to include exotic plants, pottery, rock houses, old sawmill and iron smelter sites. Rock is quarried and hauled out for use as road construction material and cobble for street pavements. Fire history is sparse but recollections are that at least two major fires have occurred since the turn of the century, the last being about forty years ago. Small fires (<1 ha) of undetermined origins occur occasionally and larger wildfires are guarded against. The greatest potential impact to the placid region may be the influx of people and associated development for recreation.

METHODS

A bibliographic search of all available literature relative to birds of the region was conducted at the libraries of National Autonomous University of Mexico (UNAM) and Autonomous University of Michoacan (UAMI) and reviewed prior to going afield. Collections and specimens were reviewed at same universities of collected field specimens. General methods included observations, collections using mist nets, transects and samples placed within different vegetation conditions.

Field methods for recording observations were made using binoculars (7 x 50) and identifying birds using the following field guides: Peterson y Chalif (1973), Blake (1953), Robbins (1966), and National Geographic Society (1989). Twenty censuses were conducted as per Reynolds et al. (1980). Random nocturnal transects of 30 minutes in duration were also used to note the presence of birds, which was recorded by observation of the individual and listening to songs/calls (Rabinovich 1984; Murie 1974). Scientific nomenclature follows that of American Ornithologists Union (1957) and common names as per Clements (1974), Birkenstein and Tomlinson (1981) and Navarro-Sigüenza (1991).

Observation sites were selected on the basis of vegetation type, with the intent to sample all types present in El Carrizal. Linear transects of 2000 m within each vegetation type were conducted as per the techniques described in Emlen (1971) and Verner (1988) and all birds observed recorded. Collections of voucher specimens were made using

Table 1. Birds of the region of Tapalpa.

Common name	Scientific name
Cattle Egret	*Bubulcus ibis*
Turkey Vulture	*Cathartes aura*
Black Vulture	*Coragyps atratus*
Red-tailed Hawk	*Buteo jamaicensis*
Gray Hawk	*Buteo nitidus*
American Kestrel	*Falco sparverius*
Inca Dove	*Columbina inca*
White-tipped Dove	*Leptotila verreauxi*
Groove-billed Ani	*Crotophaga sulcirostris*
Greater Roadrunner	*Geococcyx californianus*
Ferruginous Pygmy-Owl	*Glaucidium brasilianum*
Northern Saw-whet Owl	*Aegolius acadicus*
Whip-poor-will	*Caprimulgus vociferus*
Berylline Hummingbird	*Amazilia beryllina*
White-eared Hummingbird	*Hylocharis leucotis*
Northern Flicker	*Colaptes auratus*
Acorn Woodpecker	*Melanerpes formicivorus*
Cassin's Kingbird	*Tyrannus vociferans*
Dusky-capped Flycatcher	*Myiarchus tuberculifer*
Greater Pewee	*Contopus pertinax*
Tufted Flycatcher	*Mitrephanes phaeocercus*
Least Flycatcher	Empidonax minimus
Vermillion Flycatcher	Pyrocephalus rubinus
Western Flycatcher	Empidonax difficilis
Buff-breasted Flycatcher	Empidonax fulvifrons

(Cont'd.)

Common name	Scientific name
Rough-winged Swallow	*Stelgidopteryx serripennis*
Barn Swallow	*Hirundo rustica*
Scrub Jay	*Aphelocoma coerulescens*
Common Raven	*Corvus corax*
Bushtit	*Psaltriparus minimus*
Brown Creeper	*Certhia americana*
White-breasted Nuthatch	*Sitta carolinensis*
House Wren	*Troglodytes aedon*
Blue Mockingbird	*Melanotis caerulescens*
White-throated Robin	*Turdus assimilis*
Brown-backed Solitaire	*Myadestes obscurus*
Hermit Thrush	*Catharus guttatus*
Ruby-crowned Kinglet	*Regulus calendula*
Western Bluebird	*Sialia mexicana*
Orange-billed Nightingale-Thrush	*Catharus aurantirostris*
Gray Silky-Flycatcher	*Ptilogonys cinereus*
Longgerhead Shrike	*Lanius ludovicianus*
Hutton's Vireo	*Vireo huttoni*
Solitary Vireo	*Vireo solitarius*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*
Crecent-chested Warbler	*Vermivora superciliosa*
Yellow-rumped Warbler	*Dendroica coronata*
Townsend's Warbler	*Dendroica townsendi*
Hermit Warbler	*Dendroica occidentalis*

(Cont'd.)

mist nets in conjunction with transects. Only hurt or dead birds that were caught in nets were kept for voucher specimens as per Juarez et al. (1980).

RESULTS

A list of all birds encountered in this study is presented in Table 1. Eighty species of birds were recorded within 22 families, of which 82% of them were recorded in forest vegetation and 18% of those encountered were related to areas of agricultural activity.

The relative distribution of birds within their major habitat type, forest or agricultural areas, is presented in Table 2. Naturally, more species of birds were found to occur in the forest type, given the diversity and integration of small habitats within the forested watershed. The riparian zone is possibly the most productive for species and diversity, because of the complex components of water, soils, plants and fauna that are available to birds.

DISCUSSION

Bird studies that center their interest in the acknowledgement of the biology and ecology of the birds are of great importance in Mexico, since the need exists to know and evaluate the biotic resources that are present; and to establish an adequate basis for protection activities; and for management and sustainable use of all the resources in the country. By recognizing the relationships that occur between organisms and/or their environment, a necessary basis is formed for ecosystem management of vertebrate fauna, birds in particular, of their habitats.

Table 1.—Cont'd.

Common name	Scientific name
Grace's Warbler	*Dendroica graciae*
Wilson's Warbler	*Wilsonia pusilla*
MacGillivray s Warbler	*Oporornis tolmiei*
Yellow-breasted Chat	*Icteria virens*
Painted Redstart	*Myioborus pictus*
Red-faced Warbler	*Cardellina rubrifrons*
Slate-throated Redstart	*Myioborus miniatus*
Red Wabler	*Ergaticus ruber*
Golden-crowed Wabler	*Basileuterus culicivorus*
Rufous-capped Warbler	*Basileuterus rufifrons*
Yellow-winged Cacique	*Cacicus melanicterus*
Hooded Oriole	*Icterus cucullatus*
Northern (bullock s) Oriole	*Icterus bullockii*
Streak-backed Oriole	*Icterus pustulatus*
Hepatic Tanager	*Piranga flava*
Western Tanager	*Piranga ludoviciana*
Frayish saltator	*Saltator coerulescens*
Black-headed Grosbeak	*Pheucticus elanocephalus*
Blue Grosbeak	*Guiraca caerulea*
Indigo Bunting	*Passerina cyanea*
Varied Bunting	*Passerina versicolor*
Painted Bunting	*Passerina ciris*
Brown Towhee	*Pipilo fuscus*
Collared Towhee	*Pipilo ocai*
Lark Sparrow	*Chondestes grammacus*
Chipping Sparrow	*Spizella passerina*
Lincoln's Sparrow	*Melospiza lincolnii*
House Sparrow	*Passer domesticus*
Lesser Goldfinch	*Carduelis psaltria*
House Finch	*Carpodacus mexicanus*

Table 2. Relative distribution and abundance of species of birds relative to two major habitats, forest and agricultural areas.

Species of the forest	Species of agricultural areas
Aphelocoma ultramarina	*Bubulcus ibis*
Empidonax difficilis	*Columbia inca*
Empidonax fulvifrons	*Buteo jamaicensis*
Hylocharis leucotis	*Cathartes aura*
Eugenes fulgens	*Crotophaga sulcirostris*
Caprimulgus vociferus	*Tyrannus vociferans*
Aegolius acadicus	*Myarchus cinerascens*
Glaucidium gnoma	*Pyrocephalus rubinus*
Leptotila verreauxi	*Hirundo rustica*
Geococcyx californianus	*Corvus corax*
Certhia americana	*Sialia mexicana*
Sitta carolinensis	*Lanuius ludovicianus*
Troglodytes aedon	*Guiraca caerulea*
Regulus calendula	*Aimophila ruficeps*
Catharus guttatus	*Molothrus ater*
Turdus assimilis	
Vermivora celata	
Wilsonia pusilla	
Myioborus miniatus	
Pheucticus melanocephalus	
Myadestes obscurus	
Melanotis caerulescens	
Lepidocolaptes leucogaster	
Catharus aurantirostris	
Myioborus pictus	
Atlapetes pilieatus	

One of the most studied groups of vertebrates are birds, principally because many of them have been exploited by man for commercial ends, foods, cynegetics, or with purposes of ornate or fashion because of their beauty or their song. Besides their ecological importance, it is notable that they are important links in the food chain, being directly related to others members of their class, as well as to the rest of the flora and fauna. They belong to a group of very versatile animals because of their ability to rapidly spread to different environments. These characteristics combined with the distinct forms of foraging gives them a grand sense of scientific, economic, cultural and social importance.

In Table 1 the forest dwelling species that are emphasized, with respect to the abundance of each population, are the following: *Turdus assimilis, Myadestes obscurus, Pheucticus melanocephalus, Atlepetes piliatus, Aphelocoma ultramarina, Empidonax difficulis, Eugenes fulgens, Caprimulgus vociferus, Aegolius acadicus, Trogodytes aedon, Lepidocolaptes leucogaster, Leptotila verreauxi, Dendroica graciae* and *Certhia americana*. In the agricultural zones and open areas, such as rangelands, the species most observed were: *Pyrocephalus rubinus, Hirundo rústica, Columbina inca, Tyrannus voliferans, Corvus corax, Sialia mexicana and Lianus ludovicianus*. Furthermore, *Buteo jamaisensis y Cathartes aura* have been observed in diverse environments. Considering the variation of guilds, its noteworthy that insectivores are the most conspicuous in the study area. Now within the guild of insectivores, are two groups that feed on bark stripping insects and those that feed on insects that are trapped in flight.

An attempt to elucidate the differences between populations that comprise the bird community within the forest one can point out the following were recorded in all transects conducted during the day: *Miadestes obcurus, Turdus assimilis, Melanotis caerulescens, Catharus aurantiirostris, Mioborus miniatus, Pheuticus melanocephalus* and *Atlapetes piliatus*. In the case of nocturnal transects the following were recorded in 90% of all transects: *Aegolus acadicus, Caprimulgus vociferus* and *Glaucidium gnoma*. The species most observed in the agricultural zones were: *Pyrocephalus rubinus, Hirundo rústica, Columbina inca, Tyrannus vociferans, Corvus corax*, and *Guiraca caerulea*.

As it is seen in this study, the most important guild from the viewpoint of relative abundance in the study area are the insectivores, of which this is not unusual since from sampling the habitats there are a mixture of strata and species that produce a large number of places where the insectivores can forage. The presumed economic importance of insectivorous birds is not well documented. However, enough information is available to cite many benefits derived therefrom, some of which Otvos (1979) lists: insectivorous birds exert an influence (1) on the population dynamics of many forest insects through their direct predation, and indirectly through their influence on insect parasites and predators of prey, by spreading entogenous pathogens, or sometimes by altering the microhabitat of the prey; (2) at endemic levels, whereby they suppress and delay population build-ups to epidemic levels, and thereby increase the interval between insect outbreaks, and may actually accelerate the decline of an outbreak; (4) on the forest ecosystem by feeding on and by dispersing seeds of various plants; (5) the spread of wood rotting fungi and thus contribute to the cycling of nutrients.

CONCLUSIONS

Birds, principally the omnivores, spend the majority of the their time, by virtue of their feeding and nesting habits, near the forest floor where they forage on insects and vegetable matter. Some bird populations, such as woodpeckers and nuthatches, consume large quantities of pine bark dwelling insects. Numerous birds disperse seeds and spread hemi-parasites. There are other birds that play an important role in the pollination of plants, such as hummingbirds. Hence, because of these and many other interactions, birds have a value as a diagnostic of ecosystem health (Maurer 1992).

The diversity, abundance, etc. of forest birds is a direct function of habitat conditions and the different forms of silviculture. Furthermore, riparian areas are special habitats of great importance for the majority of bird species. In riparian areas of the southwest of USA, it has been determined that up to 60% of the species of neotropical birds use these habitats during their migrations and for nesting and rearing (Krueper 1992). Steven et al.

(1977) reported that riparian areas contain 10 times more migratory birds per hectare than other habitats. Some reasons are the quality and diversity of the riparian habitats. This is added reason to take better care of our watersheds.

There are species that are only found in unique conditions in the watershed, which suggests these species are restricted and could serve as indicator species. Additional research is needed to better assess the potential uses of birds as diagnostics of ecosystem health.

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Preliminary inventory of the mammals of the Tapalpa region

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Abstract.—There are species of mammals that can provide ecological information about how resources are being utilized, and the mammal populations can be useful in the collection of information about adverse effects upon ecosystems, since there are species that adapt to these changes. The objective of this study was to inventory the species of mammals that exist in the region of Tapalpa and to relate the presence of some species with the seasons. The methods employed include live trapping, direct observation as well as indirect methods such as identifying tracks over swept areas. Forty-six species have been identified within 8 orders and 18 families, of which the following are the most common, with the number of species indicated for each family: *Muridae* (12), *Phillostomatidae* (8), *Vespertilionidae* (4), *Mormoopidae* (3). Nine species of small mammal are included in the inventory. The ability to recognize the diversity of mammals of distinct vegetation types is important towards understanding the ecological relationships between wildlife and management of watersheds, as well as to make decisions about management and control of mammal populations that might reduce agricultural production and or forestry of the region.

INTRODUCTION

Little importance has been placed on the economical and ecological value of small mammals. In Mexico, there is little quantitative and qualitative information about mammal populations. Conflicts arise between the activities of small mammals, that naturally exist where man has settled, and man's need to produce food, fiber and other products from these same areas. These problems are present under different situations: home gardens, cultivated fields, rangelands and forests. Almost always the mammals implicated are rodents of various classes which cause damage to agricultural products that man is trying to produce. Some species are problematic and it is expensive to reduce their impact using poisons, rodenticides, or some other form of control. But there are other species, such as deer, rabbits, and other species, that are beneficial to man as food.

Although some small mammals impact forests and agricultural areas through their predation on grains and seeds (Campbell 1976, Sánchez 1978), they also have an ecological value. Some positive effects include aeration and hydration of the soil, predation upon insects, and the dispersal of spores of mycorrhizal fungi (Hamilton and Cook, 1940, Maser et al. 1978). Tree squirrels are known to be an important link between nutrient cycling, seed germination and establishment of pine trees (Maser 1994). Their absence from the ecosystem is evident in poor regeneration of pine stands. There are species of mammals that can provide ecological

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information about how resources are being utilized, and the mammal populations can be useful in the collection of information about adverse effects upon ecosystems, since there are species that adapt to these changes. The important point is to find and maintain the ecosystem's equilibrium in an effort to sustain adequate populations with good biodiversity, so that these same populations enhance the productivity of the ecosystem of which man is the major part. In this way one can utilize the ecology to improve and sustain the economy of the region. From another ecological viewpoint, small mammals are an important food source for birds of prey and mammalian predators (Hamilton and Whitaker 1979). Knowledge of their specific habitats and their relative abundance can facilitate the decision making of the ecological management of these communities.

In the Tapalpa region of the State of Jalisco, there are few faunal studies, especially regarding small mammals. In the state of Jalisco, there are a few studies that serve as references for the mammals that were collected, or other general works that report the occurrence of mammals or studies that reported population sizes of small mammals that can be used to get an idea of the populations that could be encountered in the different ecosystems. These sources can be useful in defining habitat criteria for restoration projects in zones that incurred drastic changes or areas where some habitat element was modified, as in the case of large forest fires. Hall's (1981) detailed study of the 'Mammals of North America' cites the presence of 140 and about 147 species of mammals for the states of Michoacan and Jalisco, respectively, which is a major reference mammalian studies in these states. Ceballos and Galindo (1984) reported the occurrence of 9 orders in the valley of Mexico, which have species in the Insectivora and Rodentia orders that are present in Jalisco.

For the greater part many populations of various species of mammals are considerably reduced as a result of man's activities, whether it be excessive hunting or agro-silviculture. There are many reasons for the low densities and diversity of mammals. Be it because of the necessity to produce food, fiber or other commercial products or vice, the result is the same—wildlife populations are reduced. Habitat fragmentation is an important factor that contributes to the problem, especially in a region where there is intensive use of the resources. Inventory information is important for these and other reasons. Another form in which this work is practical is in the use of wildlife in determination of environmental impacts, that are required in cases of exploitation of forests. The objective of this study was to inventory the species of mammals of the region of Tapalpa and relate the presence of some species to seasons.

STUDY AREA

Chávez-Huerta et al. (1995) describe the study area as follows. El Carrizal is a small (1,284 ha) pine forested watershed located 6 km southwest of the town of Tapalpa, Jalisco, Mexico, in the Sierra de Tapalpa (Figure 1). Elevations range from about 2,010 m at the junction of the stream (El Carrizal) and a 18 million m^3 storage reservoir (El Nogal), and 2,420 meters at the highest point. The climate is temperate and subhumid Garcia (1981). Mean annual rainfall is 901 mm and ranges from 548 mm to 1,549 mm, with 79% of the annual precipitation (717 mm) occurring between June and October (Benavides-Solorio, 1995). Rainfall during the drought season (February - April) averages about 11 mm/month. The major soil units are (Gómez-Tagle-Rojas y Chávez-Huerta, 1986): humic Andosols, chromic Cambisols and Luvisols, eutric Regosols and Litosols.

Figure 1. The study area is located south of the city of Guadalajara, in the State of Jalisco.

The dominant vegetation is comprised of mixed stands of pine *(Pinus michoacana* Martínez, *P. oocarpa* Schiede, *P. leiophylla* Schl. et Cham., *P. douglasiana* Martínez and *P. pseudostrobus* Lindl.), with occasional stands of pine-oak (*Pinus/Quercus*) complexes (Benavides-Solorio, 1987). The better stands of pine are located from mid-slope to the ridge tops. The mid-story of stands in the middle slope zone is characterized by such species as *Crataegus* and *Quercus*, which seem to extend over the watershed as a result of opening the site and timber harvest activities. The lower slopes are an assemblage of many woody species of trees, shrubs and vines. Some of the more common plants include species of *Arbutus*, *Alnus*, *Ilex*, *Persea*, and *Prunus* (Madrigal-Sánchez et al., 1995).

Chávez-Huerta et al. (1995) describe the historical and current major activities within the watershed. These include livestock grazing and timber harvest. Apparently, livestock have grazed the watershed since the Tapalpa area was settled in mid 1600's. Archeological evidence of early settlements within the watershed to include exotic plants, pottery, rock houses, old sawmill and iron smelter sites. Rock is quarried and hauled out for use as road construction material and cobble for street pavements. Fire history is sparse but recollections are that at least two major fires have occurred since the turn of the century, the last being about forty years ago. Small fires (<1 ha) of undetermined origins occur occasionally and larger wildfires are guarded against. The greatest potential impact to the placid region may be the influx of people and associated development for recreation.

METHODS

Small mammals were trapped using Sherman traps located at each of 2 line transects. Each line consisted of 25 stations with 2 traps/station. A preparation of 20% peanut butter with a 80% oat mixture was used as bait. The line transects were visited continuously over a 15 day period. Animal skins and cranium of selected samples were preserved, with the usual measurements taken as per Hill (1981). Medium sized mammals were sampled (1) using transects where animal tracks are observed and identified on dragged and cleared surfaces (Rabinovich 1980; Murie 1974) and (2) using stations with laminates for foot print impregnations, and attractants with barley-tuna-fruit mixtures. Bats were sampled by locating 5 mist nets amidst the trees at night. Sample site selection was random.

Teer (1979) pointed out that exotic species are those that are not native to the area, are introduced directly or indirectly by man the majority of the time in the case of wildlife. In this zone the feral dog *(Canis familiares)* and livestock are residents of forested areas as well as agricultural zones and are mammals that fit this category. These mammals were not sampled.

RESULTS

The 46 species of mammals reported in Table 1 for the region of Tapalpa, Jalisco are represented within 8 orders and 18 families. Species diversity was greatest for small mammals. The most common families with the number of species within it are as follows: *Muridae* 12, *Phillostomatidae* 8, *Vespertilionidae* 4, *Mormoopidae* 3.

A list of species most frequently observed during different seasons is presented in Table 2. Predators and common omnivores of general specialty were most frequently observed. Specialists, such as long-tailed weasels, were infrequent. This indicates to some extent that specific habitat conditions for specialists may be lacking or other conditions such cover, food or water. However, it is difficult to find and observe this particular group of mammals.

DISCUSSION

To make an inventory of the mammalian fauna of this area, it is necessary to sample as many major life zones as possible, given that the area is subject to various silvicultural activities and tourism, and that the variety of species can change greatly from one area to another. It is important to derive a species list for the area so it can be used in future studies and for making resource management decisions. Despite the 46 species encountered in 8 orders, there are sure to be other species yet to be accounted, considering that about 147 species of

mammals have been reported for Jalisco (Hall 1981, Ramírez-Pulido et al. 1982, Ramírez-Pulido y Castro-Campillo 1990, Ceballos y Miranda 1986).

Also listed in Table 1 are mammals of medium size occurring in the forested area of Tapalpa, Jalisco including: *Canis latrans, Urocyon cinereoar genteus, Bassariscus astutus, Procyon lotor, Mustela frenata, Conepatus mesoleucus, Lynx rufus, Dama virginianus, Dasypus novencinctus, Sylvilagus floridanus,* and *Sciurus colliaei*. These mammals were both observed and identified from tracks, excrement, burrows, chewed pine cones, etc.. Also found were such important species as white-tailed deer, which is a specie that needs to be conserved considering that their populations are depressed as reported by the inhabitants of Tapalpa. However, this phenomena is similar to other forested areas of the country as noted by Mandujano and Hernández-Arellano (1986), and Ceballos and Galindo (1984), for protected areas in the Sierra del Ajusco, where over harvesting has occurred.

The frequency with which species were observed in the transects are presented in Table 2. Given that a good sampling method is employed, there are other factors that can influence in an important manner the frequency of making an observation of an animal in the field, such as the activity of the animal, environmental disturbances, forest harvesting activities, forest fires, but frequency data can used as an indicator of the relative abundance of medium sized mammal populations. In this general sense the species most frequently observed are probably the more abundant than the least observed and vice versa. In this case, we have white-tailed deer, rabbits, raccoons, tree squirrels, coyote, fox, skunk and opossum as species with high frequency of observation throughout the year and samples. Others like the ringtail, lynx, long-tailed weasel, armadillo, and rock squirrel have not been accounted for in all the stations, and when they were observed their sign (tracks) were scarce.

Table 1. Preliminary list of mammals of the Tapalpa region.

Family	Scientific name
DIDELPHIDAE	*Didelphis virginiana*
SORICIDAE	*Sorex saussurei*
EMBALLONURIDAE	*Balantiopteryx plicata*
MORMOOPIDAE	*Mormoops megalophylla*
	Pteronotus davyi
	Pteronotus parnellii
PHYLLOSTOMIDAE	*Hylonycteris underwoodi*
	Leptonycteris sanborni
	Carollia subrufa
	Artibeus jamaicensis
	Artibeus toltecus
	Sturnira lilium
	Desmodus rotundus
VESPERTILIONIDAE	*Lasiurus borealis*
	Lasiurus intermedius
	Myotis fortidens
	Rhogeessa parvula
MOLOSSIDAE	*Molossus ater*
DASYPODIDAE	*Dasypus novemcinctus*
LEPORIDAE	*Sylvilagus floridanus*
SCIURIDAE	*Spermophilus variegatus*
	Sciurus colliaei
CEOMIDAE	*Pappogeomys gymnurus*
HETEROMYIDAE	*Liomys irroratus*
MURIDAE	*Baiomys musculus*
	Neotoma mexicana
	Peromyscus banderanus
	Peromyscus boylii
	Peromyscus perfulvus
	Peromyscus spicilegus
	Reithrodontomys fulvescens
	Reithrodontomys megalotis
	Reithrodontomys sumichrasti
	Sigmodon fulviventer
	Sigmodon mascotensis
	Mus musculus
	Rattus rattus
CANIDAE	*Canis latrans*
	Urocyon cinereoargenteus
PROCYONIDAE	*Bassariscus astutus*
	Procyon lotor
MUSTELIDAE	*Mustela frenata*
	Conepatus mesoleucus
FELIDAE	*Lynx rufus*
CERVIDAE	*Dama virginianus*

Table 2. Frequency of observation of selected mammals by season and total for the year 1994. The number of transects is indicated below the season. The English common name is presented in ( ).

ANIMAL	Spring 15	Summer 10	Fall 10	Winter 15	Total 50
Ardilla (Collie's squirrel) *Sciurus colliaei*	11	10	9	5	35
Ardillón (Rock squirrel) *Spermophilus variegatus*	6	8	7	5	26
Armadillo (Nine-banded armadillo) *Dasypus novemcinctus*	4	5	4	3	16
Conejo (Eastern cottontail) *Sylvilagus floridanus*	10	1	4	4	19
Cacomixtle (Ringtail) *Bassariscus astutus* 2	-	1	1	3	
Comadreja (Long-tailed weasel) *Mustela frenata*	3	-	-	1	4
Coyote (Coyote) *Canis latrans*	8	2	4	7	21
Gato montés (Bobcat) *Lynx rufus*	2	1	-	1	4
Mapache (Raccoon) *Procyon lotor*	6	7	2	8	23
Tlacuache (Virginia opossum) *Didelphis virginianus*	9	7	8	5	29
Zorra (Gray fox) *Urocyon cineroargenteus*	6	8	5	8	27
Zorrillo (Hog-nosed skunk) *Conepatus mesoleucus*	9	10	4	4	27
Venado (White-tailed deer) *Dama virginianus*	7	5	3	10	25

CONCLUSIONS

In the forested areas of Tapalpa, at least 46 species of wild mammals are reported to occur and this area can be considered as potential habitat for 4 other species. The list of species presented shows good composition on behalf of carnivores and omnivores. This is a good indication that there are desirable habitats remaining for these species. In order to make a better assessment of the mammals of the area, one needs to continue with the inventory to a point where rarer species, such as members of the cat (e.g. *Felis onca, F. concolor, F. pardalis, F. wiedii,* o *F. tigrina*) or wolf (e.g. *Canis lupus*) families are encountered. This latter class of mammals represent the highest trophic level of the food chain. Their absence is an indication that something is wrong, be it their habitat, prey or the prey's habitat. Hence, this group of species can serve as diagnostic species of our environment.

Given the fragmentation of the natural vegetation in the area, it is urgent to maintain the status of the less altered forested areas under a well defined silvicultural program. There is no factor more serious that causes the decline of wildlife populations as loss of habitat (Morrison et al. 1992). It is very difficult to assess the effects of habitat fragmentation, but it is clear that it results in conditions less than adequate for species with large home ranges.

The forests of the area of Tapalpa are a reserve of mammalian fauna characteristic of the portion of Occidental del Mexico, and of forest of temperate climate. The fauna that lives in these forests of the region of Tapalpa, under an adequate management plan, can contribute as an enriched element to the cultural life of the local populations and visitors to the area through environmental education programs, ecotourism and other natural resource conservationists.

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Ecosystem management for northern Mexico: Landowner perspectives at El Largo-Madera

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Abstract.—The task of developing and applying ecosystem management practices in Mexico is complicated by the ejido land ownership arrangement. The landowners, or ejidatarios, jointly own the land and are responsible for deciding, with technical support, how the land will be managed while meeting government regulations. This study reports on the results of an interview-based survey of landowners in the Ejido El Largo-Madera. The wants, needs, problems, solutions and possible new initiatives are summarized given the perspective of the landowners. Using this input goals and a vision statement for the Ejido are drafted to provide guidance for future ecosystem management initiatives.

INTRODUCTION

As in the United States, ecosystem management is receiving increased attention by our neighbor to the south, Mexico. In Mexico, this type management approach was recently emphasized in a set of sweeping environmental protection and natural resource management laws (SARH 1988, SEDUE 1988). The task of developing and applying ecosystem management practices in Mexico is complicated by the land ownership arrangement. Most forest lands in Mexico are communally-owned in what is called an 'ejido'. The landowners of the ejido, or ejidatarios, jointly own the land and are ultimately responsible for deciding how the land is to be managed, while meeting the policies and regulations set by the government. This arrangement is not unlike the situation with Native American tribal lands in the United States. In both cases the landowners rely heavily on the land as a source of employment and income. As such, ecosystem management approaches must be particularly sensitive to the wants and needs of the dependent landowners.

This socio-economic or human dimensions investigation was considered an important prerequisite to designing and implementing possible ecosystem management approaches in Northern Mexico. The Ejido El Largo-Madera located in the State of Chihuahua was chosen as a case study to examine landowner attitudes and values under the ejido system.[2]

The objectives of this study are fourfold:

- to determine the wants and needs of the ejidatarios;
- to define perceived problems and possible solutions;
- to identify what new initiatives might be acceptable;
- to provide goals and a vision statement for the Ejido.

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[2]*This socio-economic analysis of El Largo-Madera is part of a broader study, "Ecosystem Management for Lands in Northern Mexico - A Management-Research Partnership."This study involves several organizations in Mexico and the United States.*

BACKGROUND

In order to better understand the perspectives of the landowners it is important to review the history of the area as it pertains to the forests. Further the current socio-economic situation needs to be explained in order to more fully appreciate landowner attitudes and values.

History

This area of Mexico has long been involved in timber logging operations and the manufacture of wood products. In the early 1900's, what is now the Ejido El Largo-Madera, was occupied by U.S. companies who logged the area and built large-sized sawmills. At that time the Mexican government ceded the lands to the companies in exchange for the companies' constructing railroads and their associated facilities.

After the Mexican Revolution in 1910 all land concessions were re-examined and much of the companies holdings reverted to national ownership. Over the years that followed the people in the area petitioned the government to grant ejido rights to the land. By 1971, 257,000 ha were ejido properties that collectively became known as the Ejido El Largo-Madera with annexes (Orozco, 1991).

Since the landowners or ejidatarios themselves do not have the expertise necessary to manage the forest land, the government created quasi-private, quasi-public technical service organizations charged with complying with government regulations while fulfilling the goals of the landowners. These units provide professional forestry expertise and technical assistance but have no decision making power; this remains with the Ejido. The technical unit responsible for El Largo-Madera is known as the Unit of Conservation and Forest Development #2. Again this arrangement is similar to the relationship between the Bureau of Indian Affairs (BIA) and the Indian tribes in the U.S. Although in the U.S. BIA officials are federal government employees whereas in Mexico the technical unit employees are paid through the operating budget of the Ejido.

The Ejido El Largo-Madera evolved over many years mirroring the social changes impacting land ownership in Mexico. The ejidatarios are generally poor rural people dependent on the land for their economic survival. They rely heavily on the advice of the technical unit in making decisions regarding the management of their lands and attendant ejido-owned industry such as sawmills.

Current Socio-Economic Situation

The most recent census indicates that the economically active population within the Ejido consists of 10,030 people (of those approximately 1650 are ejidatarios). Approximately 70% of this population's economic livelihood is either directly dependent or derived from the Ejido's forest activities. Others depend indirectly on the Ejido as they are involved in the local service sector.

Education is a decisive factor in the social, economic and cultural development in any community. Census data indicate that 6% of the Ejido's people are illiterate. The majority of these people are adults who did not have the opportunity to receive education given distance from the schools.

The distance to schools is only part of the problem. The predominate attitude among some parents is that they consider children, particularly boys, to be potential wage earners. By the time they are teenagers, most are expected to work along side their parents and contribute to the family income rather than continuing their education. The perception is that education does not improve incomes as there is a lack of employment opportunities and young people should get whatever work they can early-on. This situation leads to a low-level of skill in the work force and aggravates unemployment as children become part of the work force when they should still be in school. It also makes it difficult to develop new employment possibilities for higher incomes since this requires a more educated work force. This state of affairs leads to chronic economic underdevelopment.

Not all families share this attitude toward education. Those parents viewing education as important will often leave their isolated settlements or small communities and move to Madera (the largest town near the Ejido) so their children can attend school. They feel a better education can be obtained there as opposed to the rural situation where only one teacher might attend to children of all ages and grade levels. However, this can also lead to social problems attendant with rural residents moving to population centers already overwhelmed with people.

Public services within the Ejido are rather poor. In the majority of smaller communities the population has access to piped in water, but it is not drinkable and service is continually interrupted. The water is untreated and contaminated but still used for cooking and cleaning thus many people suffer from gastrointestinal problems.

Most of the communities have electricity and the main ones have residential telephone service. Few communities have sewage systems and most people use latrines. This, too, contributes to the high incidence of gastrointestinal disease. The roads, in particular in small communities, are poor due to the lack of proper maintenance. Depending on the season the roads may be covered by water and mud. Housing normally consists of the adobe, cinder block or concrete wall construction with galvanized panel roofs. Floors may be cement, wood, or earthen. The bulk of these houses are privately owned, only a few are rental or loaned to the inhabitants.

The only population center in the area that may be considered a 'city' is Madera. It too lacks some basic services but it does have much more to offer than the other communities. The services available include hotels, restaurants, government offices, clinics, a hospital and, as mentioned, schools.

The situation at the Ejido El Largo-Madera depicts a struggle of people trying to achieve a higher standard of living. Their economic resilience is low and is directly related to the forest resource. Given this situation how will the people react to "ecosystem management" when their concerns are largely economic rather ecological?

PROCEDURES

A questionnaire was prepared outlining questions that would help identify wants and needs of the people, determine problems and possible solutions and help define goals and a vision statement. The two lead authors used this questionnaire to help conduct personal interviews in the Ejido in February 1994. Just prior to the interviews a radio announcement was made to inform the people of the project. To make the people feel as comfortable as possible the interviews were conducted informally in homes, work centers and offices of the Ejido. Additional informal contacts in the streets of communities were also made. A total of 134 interviews were completed in six different communities in the Ejido and included interviewing both adults and older children.

MAJOR FINDINGS

The major findings of the survey will be presented in narrative form in the following order[3]:

- What are the major problems or issues and wants and needs?
- What can be done to solve these problems and what new initiatives are possible?

What are the major problems or issues and wants and needs?

Responses to the survey indicated that people perceived one of the most significant problems within the Ejido were disorganization and poor administration. This complaint was primarily directed at the elected ejidatarios who make the decisions with the advice of the Unit's foresters. (In the ejido system a president and a committee of ejidatarios are elected to form the decision-making body.) In part, the poor administration may be attributed in some degree to the lack of ability and education of the elected ejidatarios. However, the interviewees also exhibited some lack of confidence in the Unit's foresters who are in the unpleasant condition of being caught between the landowners and meeting government regulations. All this translates into a fear of becoming involved in new ventures (e.g. ecosystem management) that may require investment of Ejido funds and might ultimately result in losing money. Uniformly, people want the organizational structure of the Ejido to change.

Not surprisingly, the people are concerned about the lack of diverse employment opportunities. The majority rely almost completely on wages from logging, although some supplement this income by raising livestock and selling agricultural crops. They worry about their high degree of dependence on the forest wood products operations. They are concerned that foreign competition

[3]In this study no attempt was made to statistically analyze the results. The narratives describe what was most frequently mentioned as a response.

(North American Free Trade Agreement) will further erode their economic resilience. Some fear that the resource will be depleted and they will lose their primary source of income. In conjunction with this they see unauthorized (illegal) cutting as a problem in certain areas and want stricter law enforcement.

The capital or economic resources needed are a concern for the landowners. The only capital they have (after wages, etc.) is now used for profit sharing among the ejidatarios. Those surveyed were concerned that to enter into new initiatives would reduce or suspend profit sharing for some time. (Of course there are other options like bank loans or outside investment.) Its clear they don't want to invest in anything that will not provide direct financial return. Further, they are reluctant to pursue new initiatives given the lack of confidence and general distrust of the Ejido leadership's ability to make them successful.

As mentioned earlier, the poor state of public services is a problem in the Ejido. This is directly related to the level of economic activity in the area. The problems with schools, and basic services leads to social conditions that generate conflicts and discord among the ejidatarios themselves. They fear this will continue in the future if their living conditions do not improve. In essence they want a safe, stable, healthy environment where they can live together in harmony.

What can be done to solve these problems and what new initiatives are possible?

Overwhelmingly people feel that the administration of the Ejido must be improved in order to solve problems. They are pessimistic that any new initiatives will be successful given the current organization. To restore confidence they want more communication, financial audits and be better informed. They also want legal action taken against those who break the law.

Interestingly the respondents understand there is much to be learned about the forest itself. They feel certain problems can be solved by them understanding more about the forest through environmental education. They realize that because of the economic situation their view has been slanted in that direction. However, they appreciate the need of a land ethic and conscience and a respect for the forest laws. With this they are open to more public education in schools and for adults concerning the forest ecosystem of which they are an integral part.

Naturally they feel many of their social and standard of living problems can be remedied by having more diversified, higher paying employment. When asked what new initiatives they thought should be pursued by far the most often mentioned was the Ejido processing wood into valued added products like finished lumber and furniture. Other initiatives mentioned, although less frequently were more cattle and sheep grazing, fish hatcheries and recreation and eco-tourism. Recreation in particular has potential as there are several archeological sites located nearby and the area is known for its trout fishing. Pursuing any of these endeavors would require the cooperation of the state government and municipal organizations. They would also require that the staffing of the Unit include additional expertise and there be worker training programs. Finally, and most importantly, they would require an investment of capital.

GOALS AND A VISION STATEMENT FOR THE EJIDO EL LARGO-MADERA

Given the findings of the study the following broad goals can be defined for the Ejido:

- Improve the administration
- Diversify the economic base and increase employment by producing and selling value-added wood products and pursuing other economically viable alternatives
- Promote forest health, protection and sustainability
- Improve education and public utilities
- Increase the standard of living

Ecosystem management can only be effective by knowing what people want for and from their forests. The "vision" the people have for their forest of the future is key to planning what needs to be done and move towards it. Visions are not forecasts, nor are they usually achievable in a perfect sense. Rather they are indicators of direction and, as such, provide an important means of communication between the leadership or management and the people. A vision statement

represents common themes that can provide direction to forest management and policy.

To capture the visions of any diverse group of people is difficult. The Ejido's people, like any society, represent a wide range of viewpoints and value systems. The authors have drafted the following vision statement for the Ejido which was approved by the Ejido's leadership.

> The administration of the Ejido El Largo y Anexos will function in an organized and equitable manner by means of strong internal regulation. The Ejido will diversify its economic base by investment in light industry which will result in the sale of processed wood. The Ejido, in cooperation with government and private investors, will establish and maintain factories for the production of value-added products, such as furniture. This will increase profits and provide employment for a larger group of people. The prospect of diverse employment opportunities in such areas as sales, production, administration and computers will provide an incentive to young people to complete their education.
>
> Public utilities within the principle communities will be improved so that people's basic needs for such services as potable water, electricity, drainage, and public security are met. Streets in the communities will be paved and maintained. The major highway will be paved reducing travel time to one hour and decreasing transportation costs.
>
> Foresters at the Unit will continue to provide the Ejido with technical services as well as ongoing educational programs that promote forest health and successful ecosystem management. The foresters will draw on the expertise of other natural resources specialists, such as wildlife biologists, hydrologists and soil scientists, to expand their management perspective.
>
> The standard of living for people within the Ejido will increase to a level commensurate with the potential value of the resources they manage.

IMPLICATIONS FOR AN ECOSYSTEM MANAGEMENT PROJECT

In order for the landowners to endorse any ecosystem management approach they must be involved at every stage of the effort. As stakeholders the landowners input must be solicited on a regular basis and they must feel shared ownership in the approach.

The situation dealing with management structure needs to change. The problems dealing with lack of communication and underlying distrust are likely to be compounded by the complexity added with the inclusion of ecosystem management. New means of communicating and management decision making need to be explored. The establishment of an organization that is trusted, accountable and communicates is more likely to result in implementable ecosystem management in the ejido system.

In addition to organization changes, it is important to institute a public education program in ecosystem management concepts for both schools and adults. It is clear the people want this kind of program. This program should involve television and radio spots, videos, and a learning center to facilitate public awareness and education. The education process needs to be long-term and updated as ecosystem management concepts are planned and applied in the Ejido.

Ecosystem management will go beyond the traditional timber emphasis that now dominates the Ejido's economy. The traditional timber-oriented management methods cannot begin to address the complicated ecological and socio-economic problems facing the Ejido. Thus, there will need to be changes in the Unit to provide expertise in other areas to meet the requirements of ecosystem management.

Finally, the concerns of the landowners are valid; timber is now their only palpable source of income. As stated by many the forest is . . . " all there is". They are naturally risk adverse and prefer to stick to activities that are known and guarantee income rather than risk the unknown and untried. Ecosystem management will only be successful if it can be accomplished in a viable economy. Anything less will be unacceptable to the Ejido's population.

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Palabras clave: sostenibilidad, manejo de ecosistemas, dasonomía internacional, manejo forestal

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CONTENIDO

PONENCIAS MAGISTRALES

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United States
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CONTENIDO

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MENSAJE DE CLAUSURA

CARTELES

PONENCIAS VOLUNTARIAS

Relatoría general

Carlos E. González Vincente

Durante los días del 17 al 20 de octubre de 1994, se llevó a cabo en la Ciudad de Guadalajara, Jalisco, México, el V Simposio Bienal México-Estados Unidos sobre Cooperación Social para el Manejo Sostenible de los Ecosistemas Forestales.

En el Simposio fueron presentadas 8 ponencias magistrales, 6 estudios de caso y se expusieron 62 carteles técnicos y científicos, de los cuales 23 correspondieron a instituciones y organismos de los Estados Unidos y 39 de México. Asistieron un total de 323 participantes, de los cuales, 72 representaron a instituciones y organismos de los Estados Unidos, 3 de Haití y 248 de México.

Las instituciones representadas fueron 8 de los Estados Unidos, 27 de México y una de Haití. Adicionalmente estuvieron representadas 12 asociaciones civiles y 6 organizaciones de productores de ambos países.

En el Simposio se destacó la importancia e impacto que ha tenido el desarrollo de proyectos de investigación cooperativos entre el Servicio Forestal del Departamento de Agricultura de los Estados Unidos y el Instituto Nacional de Investigaciones Forestales y Agropecuarias de la Secretaría de Agricultura y Recursos Hidráulicos de México, con la colaboración de otras instituciones científicas y académicas de ambos países.

Reuniones científicas que precedieron a ésta y que se llevaron a cabo en: 1) Saltillo, Coahuila; 2) Tucson, Arizona; 3) Morelia, Michoacán; y 4) Santa Fé, Nuevo México, han permitido promover, desarrollar y dar a conocer los resultados técnicos y científicos de proyectos conjuntos.

Durante el evento se abordaron los temas relativos a las bases científicas, criterios de evaluación, métodos de evaluación y manejo aplicado, todos ellos relativos a la sostenibilidad. Adicionalmente se presentaron estudios de caso sobre la participación social para el manejo sostenible de ecosistemas con fines de producción, protección y restauración de ambos países y se realizó un viaje técnico de campo a los bosques de Tapalpa, Jalisco, para conocer los proyectos de investigación cooperativos sobre manejo sostenible de ecosistemas, con la participación de los productores forestales.

En relación a las bases científicas de la sostenibilidad, se estableció la premisa de que la ciencia es indispensable para alcanzar la sostenibilidad, pero que no es suficiente.

Las bases científicas para la sostenibilidad enfrentan el problema de la gran complejidad de los ecosistemas, por lo que en la toma de decisiones al respecto, hay que realizar análisis con diferentes niveles de profundidad, que pueden ser al nivel de una célula, organismo, población, comunidad, ecosistema, bioma o biósfera.

Quien analiza la sostenibilidad de un ecosistema, debe tener el control de sus variantes, sus flujos de entrada y salida y entender que los ecosistemas no están organizados por su tamaño o su complejidad. La sostenibilidad debe entenderse como la característica de un ecosistema para mantenerse como tal, sin cambio en sus procesos y funciones ecológicas, su diversidad y su productividad a través del tiempo, manteniendo su integridad de manera permanente.

Se definió que la sostenibilidad sólo se alcanzará sí se asumen criterios de largo plazo, respetando la biodiversidad y las necesidades sociales. Sin bien hasta ahora los programas de conservación se han llevado a cabo con criterios que toman en cuenta las necesidades ecológicas, no lo han hecho en cuanto a las de carácter social y económico.

Respecto a los criterios para evaluar la sostenibilidad, se indicó que éstos deben considerar los diferentes sistemas de producción y servicios de acuerdo a su destino, definiendo sus límites de acción y cuidando que los procesos sean económica y socialmente viables, ya sea por si mismos o subsidiados.

Para definir los criterios que permitan cuantíficar la sostenibilidad, es necesario tomar en cuenta que las principales funciones de la biósfera

[1]*Vocal de la División Forestal del INIFAP, SARH.*

son las de suministrar materias primas, asimilar los productos excedentes de las actividades humanas (residuos) y proveer los servicios ambientales como la calidad del aire.

Se concluyó que la evaluación de la sostenibilidad debe ser tanto cualitativa como cuantitativa, tomando en cuenta los patrones ambientales y las actividades humanas en el tiempo y en el espacio, lo que permitirá evaluar la efectividad de las políticas públicas establecidas y detectar oportunamente cambios no deseados.

Sobre los métodos para evaluar la sostenibilidad, se indicó que es necesario seleccionar indicadores, diseñar los modelos y cuidar la calidad y el manejo de la información. En la evaluación de la sostenibilidad se requiere el uso de metodologías que faciliten la interpretación de los datos, la definición de las diferentes escalas y la periodicidad de las mediciones, las facilidades logísticas para su aplicación práctica y los costos que involucran.

Para destacar el manejo forestal aplicado a la sostenibilidad, se hizo notar la necesidad de evitar las medidas extremas que en ocasiones se han tomado para promover la conservación y restauración, tales como las vedas forestales. El manejo sotenible solo se logrará cuando se parta de la premisa de que los recursos naturales y el hombre son parte del ecosistema. Además, como funciones productivas deben considerarse los servicios ecológicos que se obtienen a partir de los recursos forestales.

En los planteamientos de sostenibilidad subyacen algunas contradicciones que deben ser tomadas en cuenta y requieren ser resueltas, entre las que destacan: productor-consumidor, productor-recursos naturales, sociedad-recursos naturales y socieldad-agricultura de subsistencia.

En cuanto al manejo forestal, también se hizo notar que en las experiencia desarrolladas en el noroeste de los Estados Unidos, para dar sostenibilidad a los procesos ecológicos se definen con claridad los objetivos y se desarrollan proyectos orientados hacia ellos. Los proyectos incluyen la caracterización de los recursos, sus funciones y los procesos ecológicos con sus interrelaciones, asumiendo que el manejo sostenible requiere de imitar a la naturaleza.

En las experiencias desarrolladas, las actividades que se han realizado, incluyen el modelo de manejo de cuencas, identificando las especies existentes y sus niveles de perturbación, las necesidades de la población, los tratamientos silvícolas mas adecuados y en esta forma determinar las condiciones mas deseables a los diferentes niveles del ecosistema y las acciones requeridas para llegar a ellas. La estrategia para el manejo sostenible es a largo plazo y demanda la coordinación de esfuerzos, la identificación de las diferentes escalas de problemas, la instrumentación de los métodos de manejo y la detección de los impactos ecológicos con el apoyo de resultados de la investigación.

Con el propósito de analizar las experiencias prácticas sobre la concertación social para el manejo sostenible de los ecosistemas, durante el Simposio se presentaron seis estudios de caso de México y de Estados Unidos, habiéndose concluido como puntos mas relevantes los que se resumen a continuación.

El Plan de Manejo de Recursos Forestales en Quintana Roo, México, se distingue por la participación del sector social en el manejo sostenible de sus bosques tropicales naturales.

Para la operación del plan, se partió de una fase de diagnóstico, desarrollada en el año de 1982 y a partir del próximo año, se iniciaron las actividades operativas, partiendo de la premisa de que para conservar la selva son imprescindibles sus funciones productivas. El plan incluyó programas de manejo forestal, organización de productores, capacitación campesina, industrialización y comercialización de productos.

El desarrollo del plan de manejo ha producido como resultados mas importantes la disminución del proceso de destrucción de la selva, el aprovechamiento racional de las áreas forestales permanentes con un volumen anual de madera de 13 mil metros cúbicos, la promoción de actividades de manejo de la fauna sílvestre y ecoturismo, así como obras de beneficio social con las utilidades obtenidas por la comunidad. destaca en este proceso, que los servicios técnicos forestales, fueron transferidos a los productores.

Sobre el desarrollo del Proyecto de Manejo de Ecosistemas del Río Chattooga, que se lleva a cabo en los estados de Carolina del Norte, Carolina del Sur y Georgia, en el Sureste de los Estados Unidos, en terrenos de propiedad privada y nacionales, se hizo notar que los objetivos principales están orientados hacia el manejo forestal y a la conservación de mantos acuíferos. En el proyecto, la participación social es un factor fundamental para la

conservación de la calidad del agua, la restauración de arroyos, el mejoramiento de la ganadería y la preservación de la biodiversidad.

Los principales agentes de disturbio que se han identificado son la agricultura, el aprovechamiento forestal, la erosión eólica y los incendios.

Con el apoyo de instituciones científicas se definieron los patrones de manejo deseados y se ha iniciado el desarrollo metodológico para alcanzarlos. En cuanto al manejo de recursos naturales se trabaja con escalas múltiples, tanto en el tiempo como en el espacio. A través de los programas de investigación y desarrollo, se han detectado los valores y servicios que la población desearía obtener de los recursos naturales y se han desarrollado modelos de manejo, sustentados en sistemas de monitoreo. En forma particular se pretende determinar en que medida se afecta la propiedad privada por el uso que se les da a los terrenos nacionales y viceversa.

Como estudio de caso, también fue presentada información sobre el Proyecto de Manejo Sostenible de Ecosistemas del Río la Petaca, Estados Unidos, que tiene como objetivo armonizar el uso del suelo con los intereses culturales de los grupos étnicos en una superficie de 200 mil acres, en un ecosistema de piñoneros y enebros.

En este caso, la comunidad indígena ha demandando conservar en forma sostenible la calidad del agua y del aire, una mejor regulación para el aprovechamiento de sus recursos naturales y el desarrollo de la comunidad rural. En contraste, los grupos hispanos pretenden la ganadería extensiva de ovinos y el grupo anglosajón busca usos mas intensivos y esquemas de cooperación que permitan un manejo sostenible de los recursos.

En función de las actividades productivas y de las demandas, el manejo de los recursos se orientó hacia la producción de leña para generar energía, el mejoramiento de la ganadería, de los servicios para la recreación y de la infraestructura de caminos.

Respecto al estudio de caso del Programa de Manejo, Conservación y Protección del Desierto de los Leones, México, se destacó el modelo integral desarrollado para evitar los efectos negativos del mal manejo silvícola, la presión urbana y la contaminación atmosférica.

A partir del desarrollo de un buen inventario forestal, se ha establecido un plan de manejo técnico de los recursos, que considera las características de los sistemas hidrológicos, de la fauna silvestre, forestal y recreacional.

Respecto al Plan de Manejo Integral de las Cuencas de Pátzcuaro y Zirahuén, en Michoacán, México, se destacó que es una respuesta a los graves problemas ambientales que durante siglos ha provocado el mal manejo de los recursos naturales de la región.

En este caso, con la integración de un grupo interdisciplinario de técnicos y científicos, se procedió al diagnóstico integral del área y posteriormente a la jerarquización de los problemas mediante el empleo de estudios cartográficos y de sistemas de información geográfica, que han permitido definir el potencial productivo de las cuencas hidrográficas. La operación del plan se ha realizado mediante la integración de 85 programas de acción inmediata, orientados en un principio a proporcionar los servicios básicos a la población rural.

Como último estudio de caso, se presentó información sobre el Programa de Manejo Sostenible del Lago Tahoe en los Estados Unidos. Se destacó que la región estudiada cubre una superficie de 500 millas cuadradas, en las que durante siglos los aprovechamientos mineros y la presión demográfica, han provocado graves perturbaciones. En esta región los programas de manejo sostenible estan orientados al mejoramiento de las características del aire y de la calidad del agua. También se realizan esfuerzos para evitar la declinación del bosque debido a ataque de plagas y al cambio de las especies.

Para la región del Lago Tahoe, fue desarrollado un Plan Maestro Interestatal, que se ha puesto en operación con muy buenos resultados mediante la participación de las autoridades y de la sociedad.

Las recomendaciones de carácter general del Simposio se resumen en las siguientes:

- Se reconoció que no obstante que los enfoques para atender los problemas que plantea la sostenibilidad son los correctos, aun se requiere de mucho trabajo para encontrar las soluciones.

- Se enfatizó la conveniencia de que, tanto la investigación como la administración de los recursos, tomen en cuenta las diferentes escalas en que puede ser considerada la sostenibilidad de los recursos naturales.

- Hubo consenso en que la sostenibilidad se debe manejar tanto en el tiempo como en el espacio y que debe ser técnicamente viable, económicamente posible y socialmente aceptable.
- Respecto al enfoque sostenible de los programas de desarrollo rural, se hizo énfasis en la necesidad de tomar en cuenta a todas las actividades del sector primario, en especial a la agricultura, ganadería y silvicultura.

Mensajes de inauguaración

MENSAJE DEL ING. SALVADOR PRECIADO RAMÍREZ[1]

Tengo el alto honor de asistir a esta importante reunión internacional, con la representación del señor Secretario de Agriculturatura y Recursos Hidráulicos, quien transmite por mi conducto sus más calurosos saludos y sus mejores deseos para el éxito de este V SIMPOSIO SOBRE COOPERACIÓN SOCIAL PARA EL MANEJO SOSTENIBLE DE LOS ECOSISTEMAS FORESTALES.

La creciente preocupación por el uso adecuado de los recursos naturales está invandiendo todas las esferas de participación del hombre. Se ha entendido que la naturaleza puede vivir sin la presencia del hombre, pero éste no podrá hacerlo sin preservar adecuadamente la naturaleza.

Este evento, que reune a científicos de ambos países y a ciudadanos preocupados por dar el mejor uso a los recursos naturales tiene la particular relevancia de conjuntar esfuerzos para lograr que estos recursos puedan continuar aportando, en forma creciente, los bienes y servicios que demanda la existencia de la sociedad actual, sin que esto implique la destrucción y el deterioro irreversible de los mismos.

Pretende también poner en aplicación los adelantos que en materia técnico-científica se están generando en otras partes del mundo para la preservación de los ecosistemas naturales. nuestros países, que tienen ya una larga tradición de acciones cooperativas llevan más de tres lustros realizando esfuerzos para lograr que los recursos naturales de los bosques, selvas y zonas áridas se preserven e incrementen para dejarlos en mejores condiciones a las generaciones futuras.

Deseo agradecer a todas las organizaciones que han sumado sus esfuerzos para la realización de este Simposio, en el que además de los investigadores se tiene la participación de los productores forestales, grupos ecologistas, industriales e instituciones de enseñanza e investigación en materia forestal que han venido haciendo importantes aportaciones para alcanzar los propósitos que desde el inicio de estas reuniones se establecieron como metas comunes.

En la pasada reunión que se llevó a cabo en la ciudad de Santa Fé en el Estado Nuevo México, se mencionó que lo que es trascendente requiere tiempo para alcanzarse; por esta virtud estamos seguros que las aportaciones que en esta reunión se harán, darán mayores luces a las soluciones que se plantearán para resolver los graves problemas de deterioro ambiental y además facilitarán las decisiones que deban tomarse para el manejo adecuado de cuencas hidrográficas; la protección y conservación de la fauna silvestre; la restauración de áreas con serios conflictos de conservación y la preservación de especies en peligro de extinción. Esto permitirá dar a nuestras actividades un rumbo definido para los próximos años.

La Subsecretaría Forestal y de Fauna Silvestre, rectora de las actividades forestales de México, ha venido impulsando cada día todas las actividades relacionadas con la protección, conservación e incremento de los recursos naturales que componen a los tres principales ecosistemas del país, bosques, selvas y zonas áridas, que por su naturaleza y composición ocupan el cuarto lugar del mundo, en cuanto a número de especies se refiere. Este apoyo ha venido siendo complementado con la participación de las comunidades rurales cada vez más conscientes de la importancia que reviste su conservación y mejoramiento.

Se ha definido la sostenibilidad como el proceso que lleva a la satisfacción de las necesidades del presente sin comprometer la capacidad para que las futuras generaciones puedan resolver las propias, esto establece la obligación nuestra del uso racional de los recursos naturales disponibles y el compromiso de heredarlos en mejores condiciones a los pobladores futuros de ambos paises.

Las deliberaciones a las que se llegue en esta reunión, después de escuchar los puntos de vista de los expertos en las ponencias magistrales; en los estudios de caso sobre producción, protección y recuperación de ecosistemas, así como las que se deriven de la presentación de los más de setenta carteles en los que los investigadores exponen sus

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[1]*Delegado de la Secretaría de Agricultura y Recursos Hidráulicos en el Estado de Jalisco.*

mejores ideas sobre este importante tema , dispondremos de mejores herramientas para proponer alternativas viables para las proximas décadas. seguramente que podremos hacerlo porque estamos unidos en un esfuerzo que alcanza a la humanidad entera.

Agradezco muy cumplidamente al Gobierno de Jalisco ser el amable anfitrión de esta reunión internacional y a todos los participantes por su esfuerzo en la presentación de documentos que formarán parte de la memoria final del evento que será material de consulta sobre el debatido tema de la sostenibilidad.

Muchas gracias a todos y mucho éxito.

MENSAJE DEL ING. CARLOS MORALES TOPETE[2]

Tengo el alto honor de asistir a esta importante reunión internacional, con la representación del Señor Secretario de Agricultura y Recursos Hidráulicos, quien transmite por mi conducto sus más calurosos saludos y sus mejores deseos para el éxito de este V Simposio Bienal México-Estados Unidos de América, con el tema: Cooperación Social para el Manejo Sostenible de los Ecosistemas Forestales.

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Este evento, que reune a científicos de ambos paises y a ciudadanos preocupados por dar el mejor uso a los recursos naturales, tiene la particular relevancia de conjuntar esfuerzos para lograr que estos recursos puedan continuar aportando, en forma creciente, los bienes y servicios que demanda la existencia de la sociedad actual, sin que esto implique la destrucción y el deterioro irreversible de los mismos.

Pretende también poner en aplicación los adelantos que en materia técnico-científica se estan generando en otras partes del mundo para la preservación de los ecosistemas forestales. Nuestros países, que tienen ya una larga tradición de acciones cooperativas, llevan más de tres lustros realizando esfuerzos para lograr que los recursos naturales de los bosques, selvas y zonas áridas, se preserven e incrementen para dejarlos en mejores condiciones a las generaciones futuras.

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[2]*Vocal Ejecutivo del Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), SARH.*

uso racional de los recursos naturales disponibles y el compromiso de heredarlos en mejores condiciones a los pobladores futuros de ambos países.

Las deliberaciones a las que se llegue en ésta reunión, después de escuchar los puntos de vista de los expertos en las ponencias magistrales; en los estudios de caso sobre producción, protección y recuperación de ecosistemas; así como las que se deriven de la presentación de los más de setenta carteles en los que los investigadores exponen sus mejores ideas sobre este importante tema, dispondremos de mejores herramientas para proponer alternativas viables para las próximas décadas. Seguramente que podremos hacerlo porque estamos unidos en un esfuerzo que alcanza a la humanidad entera.

Agradezco muy cumplidamente al Gobierno de Jalisco ser el amable anfitrión de esta reunión internacional y a todos los participantes por su esfuerzo en la presentación de documentos que formarán parte de la memoria final del evento, que será material de consulta sobre el debatido tema de la sostenibilidad.

Muchísimas gracias a todos y mucho éxito.

MENSAJE DEL LIC. CARLOS RIVERA ACEVES[3]

Para el pueblo y el Gobierno de Jalisco es altamente satisfactorla y grata la presencia de todos ustedes, reconocidos profesionales y productores forestales de los Estados Unidos y de México.

El tema de la Cooperación Social para el Manejo Sostenible de los Ecosistemas Forestales, es un tópico que estimamos de la mayor importancla y trascendencia; porque se inserta en la creciente preocupación y en las acciones de nuestros gobiernos para fortalecer la cultura y la conciencia forestal y ecológica.

Lo advertimos así, porque la educación es condición para arribar a patrones de conducta que nos permitan a todos continuar modificando las actitudes y los comportamientos para seguir construyendo el desarrollo de la sociedad, sin comprometer la capacidad de nuestros recursos, para que las futuras generaciones puedan satisfacer sus propias necesidades.

[3]*Gobernador Constitucional del Estado de Jalisco, México*

La producción de alimentos agrícolas y pecuarios, así como la de otros satisfactores que tienen su origen en el campo, no es válido manejarla de manera segmentada, ya que como parte de los entornos del medio y de la acción del hombre es necesariamente complementaria.

Es en ese sentido que se trabaja para un desarrollo integrado y sostenible. Jalisco es, en el contexto nacional de México, una entidad de la mayor importancia por su producción agroalimentaria; cada año, el trabajo de sus agricultores y ganaderos, aporta del orden de 17 millones de toneladas de productos diversos; destacando el maíz, la caña de azúcar, el mezcal tequilero, los forrajes y diversos frutales y hortalizas; así como las aportaciones de carne de bovino, porcino, pollo, huevo y leche.

En el renglón forestal nuestro potencial es amplio; actualmente el Estado ocupa el cuarto lugar nacional por su cosecha de maderas y productos como resinas y orégano entre otros.

Los productores y el gobierno, estamos empeñados en que las políticas para el desarrollo del campo sean acordes a las realidades de nuestro tiempo. Por una parte, desde su base jurídica, dando seguridad y permanencia a las posibilidades de inversión en el campo y por la otra, recreando nuevos esquemas de organización; tecnología y apoyos diversos; para que frente a la apertura comercial, aprovechando más y mejor nuestros potenciales productivos seamos competitivos.

En el campo y en el resto de los sectores económicos, no perdemos de vista que nuestro objetivo es el hombre y el bienestar de sus familias; por eso, pese a las dificultades que los cambios conllevan estamos empeñados y trabajando por un desarrollo armonioso y justo.

Con PROCAMPO estamos impulsando acciones que redistribuyan los ingresos y que progresivamente restauren el medio; alentando trabajos de sostenibilidad con acciones como labranza de conservación, mejoramiento de suelos e incorporación de materia orgánica.

También estamos fomentando la rehabilitación de las zonas de pastoreo como estrategia de salvaguarda a los espacios eminentemente forestales y entre otras acciones intensificando como nunca las tareas de prevención, control y combate de los factores que más destruyen a las zonas arboladas como son los incendios, las plagas y las cortas clandestinas de árboles.

Por otra parte, éste año de 1994, además de haber creado una infraestructura permanente y de alta tecnología para la producción de planta forestal, los jalicienses nos debemos sentir orgullosos por haber plantado en toda la entidad más de 22 millones de arbolitos, hecho de mayor significación porque representa un esfuerzo más allá de lo realizado en los últimos 12 años, esfuerzo al que habremos de darle continuidad.

Este hecho sólo fue posible por la cooperación social, con la que la ciudadanía se sumó al programa, de ahí la importancia de la tesis lema de este Quinto Simposium Bienal México–Estados Unidos.

Del resultado de los trabajos que hoy se inician y de las observaciones que se deriven de sus visitas de campo, habremos de retomar líneas de acción para fortalecer los programas emprendidos.

Dicho lo anterior y a nombre del pueblo y del Gobierno del Estado de Jalisco; hoy 17 de octubre de 1994, me resulta particularmente honroso declarar inaugurados los trabajos del Quinto Simposium Bienal México-Estados Unidos.

Muchas gracias.

PONENCIAS MAGISTRALES

Sostenibilidad: Una cuestión de valores humanos en un marco material

T. F. H. Allen[1] y Thomas W. Hoekstra[2]

Resumen.—Este artículo descompone el tema de la sostenibilidad en tres partes. En primer lugar, presentamos las bases filosóficas del planteamiento que tomamos. Segundo identificamos los problemas de trabajar con una estructura biofísica que, desde el punto de vista convenciónal de sostenibilidad, es aquello que debe ser sostenido por ecologistas, conservacionistas y manejadores del recurso. Tercero, identificamos que todo se perderá a menos que el contexto social del sistema biofísico, sea traido a una condición sostenible. Sólo cuando nuestro marco intelectual es presentado, se puede reconocer la utilidad especial de nuestro punto de vista. Sólo cuando uno entiende las dificultades de trabajar con las complicaciones de la mecánica de las plantas, animales, suelo, clima y sus interacciones, puede uno esperar tomar acción que tenga consecuencias predecibles. Sólo cuando el manejador opera en un escenario social sostenible, uno de justicia social y viabilidad económica, puede uno esperar poder sostener el curso de las acciones del plan.

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Bases científicas de la sostenibilidad

Alejandro Velázquez Martínez[1], Héctor de los Santos Posadas[2] y Tangaxuhan Llanderal Ocampo[2]

Resumen.—Este trabajo presenta una visión general de las bases científicas de la sostenibilidad, entendida como la forma de garantizar el nivel de aprovechamiento y permanencia de los recursos naturales a largo plazo. Se incluye la evolución del concepto, sus bases científicas y tecnológicas y se establece al "manejo de ecosistemas" como una alternativa viable para la sostenibilidad de los recursos forestales.

INTRODUCCION

En la historia de la humanidad, las diferentes culturas se han caracterizado por la forma de explotación sobre el ambiente y sus recursos. En los tiempos modernos la forma de explotación de los recursos es crucial, en virtud de que antes, el tipo de presiones que se ejercían eran locales y no globales. La enorme presión demográfica actual no permite la absorción de los efectos ni la recuperación de los ecosistemas a las tasas actuales de explotación. Se requiere, por tanto, de un nuevo tipo de desarrollo que sostenga el progreso de la humanidad, en el planeta entero y por tiempo indefinido.

Ante esta situación, el uso de los recursos naturales debe darse bajo el principio de sostenibilidad. La sostenibilidad, en concepto, es resumible llanamente como "el garantizar el nivel de aprovechamiento y permanencia de los recursos naturales a largo plazo" (entendiendo recursos en un espectro amplio; es decir, no sólo como madera en el caso del aprovechamiento forestal, sino también los bienes tangibles e intangibles asociados).

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El concepto de sostenibilidad incorpora el hecho de que aquellos recursos naturales considerados como renovables, sólo lo son bajo un cierto status quo. Cuando éste se altera, su condición de "explotabilidad infinita" en el tiempo, es sólo un espejismo.

En un mundo cambiante, sin fronteras ni distancias insalvables, los procesos cualitativos y cuantitativos de globalización repercuten inevitablemente. Cuantitativamente, el cambio climático global que está ocurriendo como consecuencia de la liberación excesiva de CO_2 y que se estima resultará en un incremento de entre 1.5 y 4.5 °C en los próximos 50 años. Este fenómeno no es sólo resultado del alto consumo de combustibles fósiles durante el presente siglo, sino que debemos añadirle el proceso acelerado de conversión de los terrenos forestales a agrícolas en los países en vías de desarrollo. Cada año, por desforestación, se pierden 17 millones de hectáreas arboladas. En consecuencia, 24 millones de toneladas de suelo/año son arrastradas por los torrentes. El proceso de desertificación avanza a una tasa de seis millones de ha/año. Cualitativamente, estos cambios repercuten en la condición actual de los recursos forestales del mundo, sobre todo en los países en desarrollo: bosques dimensionalmente empobrecidos, en las condiciones de suelo, biodiversidad y productos asociados; además de no representar una alternativa económica para sus poseedores.

Asociados a estos cambios cualitativos tenemos: a) políticas sociales sin las suficientes bases ecológicas y económicas que permitan el éxito en el mediano y largo plazos de los planes de desarrollo y b) el impacto indirecto de la tecnología de industrialización de los productos maderables, que en términos reales se ha vuelto más intensivo y ha modificado las condiciones de los bosques y el manejo tradicional.

SOSTENIBILIDAD: CONCEPTOS Y EVOLUCION

Hablar de manejo sostenible de los recursos forestales requiere dejar en claro qué es la sostenibilidad. Las definiciones existentes de este concepto son muy variadas y no necesariamente entran en conflicto, en virtud de que reflejan la orientación intelectual de los autores. La sostenibilidad es originalmente un concepto ecológico, que refleja "el comportamiento prudente" de un maderero que evita la sobre-explotación de su masa para asegurar un rendimiento sostenido óptimo (Odum, 1971).

En la más pura concepción del manejo forestal, el término sostenibilidad, es la habilidad de un ecosistema para mantener sus procesos y funciones ecológicas, su diversidad biológica y su productividad a través del tiempo (Kaufmann et al., 1994), manteniendo su integridad (Overbay, 1992). Este concepto también indica la habilidad para mantener una condición deseada o flujo de beneficios sobre el tiempo (Overbay, *op. cit.*). Asimismo, indica la adopción de un nivel de cosecha y actividades de manejo que pueden ser mantenidas indefinidamente (Perry, 1988). Adicionalmente el concepto de sostenibilidad reconoce otros bienes que generalmente no están asociados a un valor comercial.

En este contexto, el término sostenibilidad da una noción ecológico-biológica, a la cual es posible introducir algunas modificaciones de carácter económico y ambiental.

De esta manera, al hablar de sostenibilidad en el manejo de los recursos forestales, se debe buscar el mantenimiento de la integridad física y biológica del ecosistema, cumpliendo con las necesidades de la población a través de la implementación de estrategias y prácticas que cumplan con las políticas de aprovechamiento (SAF, 1993). Esto requiere una integración de disciplinas científicas, la aplicación de estrategias de manejo forestal y la presencia de científicos trabajando en conjunto con los administradores de los recursos naturales y con el público.

La sostenibilidad ha sido frecuentemente usada como sinónimo del rendimiento sostenido. Esto ha llevado a los expertos, a definir claramente la frontera entre una y otra, aunque cabe aclarar que están estrechamente relacionadas.

La sostenibilidad significa lo mismo que el mantenimiento de la productividad a largo plazo (pero no significa la maximización de producción maderable en un turno definido) (Perry, 1988). Por el contrario, si cortamos un rodal bajo el criterio de maximizar la producción, la consecuencia en el largo plazo, será la reducción de la productividad (Gordon, 1993).

El significado tradicional de rendimiento sostenido, se refiere a las áreas forestales manejadas individualmente para obtener un flujo más o menos regular de productos, restringiéndose su explotación por la necesidad de minimizar posibles impactos negativos al ambiente. La sostenibilidad en cambio, tendrá que enfocarse al mantenimiento de las funciones ecológicas, perpetuando el flujo de productos y, a la vez, manteniendo y logrando condiciones deseadas de los ecosistemas y sus habitantes (SAF, *op. cit.*).

EL ENFOQUE DE DESARROLLO SOSTENIBLE

El concepto de sostenibilidad debe entenderse como una concepción integral que logre una visión más global; por ello, la sostenibilidad se ha asociado al término desarrollo, generando el binomio desarrollo sostenible, que entre otras cosas ha reconciliado dos actividades consideradas opuestas: el desarrollo y la conservación (Del Amo y Ramos, 1994).

La Comisión Mundial sobre el Medio Ambiente y el Desarrollo, define el desarrollo sostenible como aquél que satisface las necesidades de las generaciones actuales sin comprometer la capacidad de las generaciones venideras para satisfacer sus propias necesidades (WCED, 1987). El desarrollo sostenible contempla el manteni-

miento de la calidad de vida, que necesariamente implica la protección de los sistemas naturales, así como los cambios estructurales sobre el tiempo, es decir, mientras estos bienes no sean escasos, esto no afecta la sostenibilidad de la producción económica y el crecimiento, así como el bienestar humano (Bartelmus, 1994).

El desarrollo sostenible no implica un patrón único de desarrollo. Este debe darse en varios niveles de actividad económica y calidad ambiental y bajo diferentes condiciones políticas, sociales y culturales (CIDA, 1991). La meta fundamental consiste en alcanzar un nivel de bienestar económico "razonable" y distribuido equitativamente, que pueda perpetuarse en forma continua en provecho de las futuras generaciones (Del Amo y Ramos, *op. cit.*).

De esta manera, es conveniente señalar al desarrollo sostenible como un proceso dinámico que nos permite alcanzar fines diversos, teniendo como meta, conducir al mundo hacia un futuro más deseable, orientando patrones de desarrollo, estrategias, métodos y actitudes (CIDA, 1991).

Como se puede apreciar, el desarrollo sostenible implica la conjunción de diversas disciplinas, ya que en este concepto están incluidos aspectos y problemas de orden social, económico y político, situaciones que le dan un carácter holístico.

En la práctica, se debe distinguir entre el crecimiento sostenible y el que no lo es, para lo cual se requiere del conocimiento detallado de las interrelaciones biológicas y de una visión geográfica amplia (Mathews, 1991). Lo que sí es importante señalar, es que el desarrollo sostenible se refiere a la producción a largo plazo de bienes y servicios con un mínimo de deterioro ambiental y de los recursos, y que dicha producción sea económicamente viable y socialmente aceptable (Ffolliott *et al.*, 1993).

Las principales características del desarrollo sostenible, de acuerdo con la CIDA (1991) son:

- El desarrollo sostenible asume una perspectiva a largo plazo

  La toma de decisiones en los gobiernos y el sector privado, se da en un horizonte de tiempo demasiado corto. El desarrollo sostenible requiere de un énfasis a largo plazo.

- El desarrollo sostenible respeta la diversidad/pluralismo

  La diversidad contribuye a la capacidad de los ecosistemas de absorber impactos negativos y mantenerse en funcionamiento; el mantenimiento de la diversidad biológica es un requisito para asegurar que los recursos naturales estarán disponibles para el uso de otros en el presente y en el futuro. Asimismo, el pluralismo de opiniones es una condición necesaria para el desarrollo político.

- El desarrollo sostenible usa un enfoque integrado

  Reconoce que los procesos naturales y humanos están íntimamente ligados. La naturaleza condiciona lo que las sociedades son capaces de lograr. Los humanos influyen sobre la naturaleza de manera benéfica o dañina y un desarrollo sostenible sólo puede ser posible mediante el entendimiento de los complejos vínculos entre los sistemas social y natural.

- El desarrollo sostenible requiere equidad y justicia

  En el contexto del desarrollo sostenible, la equidad se da en tres niveles:

  - dentro de los países,
  - entre países,
  - entre generaciones.

Es en el tercer nivel, donde la mayoría de los principios de la sostenibilidad descansan, ante el requerimiento de que las expectativas de las generaciones futuras no se vean comprometidas por las actividades de las generaciones actuales. Aunque es imposible predecir con exactitud los intereses de las generaciones futuras, es prudente asumir que sus necesidades de recursos naturales (agua, suelo, aire, bosques, biodiversidad, energía) no serán marcadamente menores que las del presente y pueden, de hecho, ser mayores.

- El desarrollo sostenible descansa en métodos participativos

Esto significa que el público debe estar involucrado en la toma de decisiones. El desarrollo sostenible necesita del conocimiento y apoyo comunitario.

Si retomamos el concepto de manejo sostenible de los recursos forestales, entonces se puede establecer que una sociedad será ecológicamente sostenible cuando sea capaz de:

- Conservar el sistema ecológico de soporte para la vida y la biodiversidad,
- Asegurar el uso de los recursos renovables en forma sostenible y minimizar el agotamiento de los recursos no renovables,
- Mantener o manejar la capacidad de carga de los ecosistemas.

FUNDAMENTOS DE LA SOSTENIBILIDAD

El concepto de sostenibilidad es, en esencia, fronterizo; es decir, más que representar a una disciplina o rama específica del conocimiento, se entiende como una filosofía, una filosofía científica.

Entendiendo este concepto, es lógico pensar en un esquema técnico-científico en el cual se base la sostenibilidad. En la base coordinada de un conjunto de disciplinas, a grandes rasgos tendríamos a las ciencias biológicas puras y fronterizas, las ciencias económicas y sociales, las ciencias políticas y la tecnología.

La interrelación de cada una de éstas es absolutamente necesaria a fin de evitar errores irreparables. e.g., en México durante los años 60's y 70's la política demográfica del gobierno favoreció la colonización de terrenos de eminente vocación forestal. A fin de reducir la presión social, se dieron diversos programas de desarrollo en base a la ampliación de la frontera agrícola. El saldo: se ha perdido el 67% de la superficie total de los bosques tropicales del país, convertidos estos actualmente en potreros o zonas de agricultura. Como resultado el medio ambiente natural se ha fragmentado y no se ha solucionado el problema inicial: la demanda social. En un suelo degradado, no apto para el más rústico de los cultivos o el pastoreo, sólo sigue el abandono. Es preciso recalcar que la mayoría de las barreras para el manejo sostenible no son de tipo tecnológico.

Las alternativas posibles del manejo sostenible sólo se entienden como resultado de una demanda social, dentro de un marco jurídico, bajo una condición económica dada y que represente una decisión política técnicamente respaldada.

El manejo sostenible, como herramienta, se considera una función casi directa de la variabilidad natural del ecosistema, de la complejidad de las demandas sociales, de la cultura y de la coordinación de la estructura legal como un instrumento de política.

La tecnología actual está demostrando ser adaptable a los problemas del manejo sostenible. Las nuevas tecnologías deberán integrarse como parte de la solución, sin olvidar que sólo representan parte de la solución. En principio se están dando pasos importantes en los países más tecnificados hacia lo que debe ser o se debe tener en cada país como requerimientos mínimos para lograr el manejo sostenible de los recursos en términos de sistemas modernos de explotación, organización, conservación y monitoreo.

Componente biofísco

La sostenibilidad del ecosistema requiere que se retengan a largo plazo los tipos de formas físicas y biológicas presentes, así como sus funciones y procesos, debiendo ocurrir esto en todos los niveles de organización; es decir, desde un microorganismo del suelo hasta los ecosistemas mayores (SAF, op. cit.).

Los componentes biofísicos fundamentales son: suelo, vegetación, fauna y las numerosas interacciones entre éstas (Perry, 1988; Velázquez, 1992; SAF, 1993). El suelo, fundamental para la sostenibilidad, es el principal componente de la productividad forestal. Las investigaciones realizadas en masas forestales han proporcionado un cúmulo de información que ha servido de apoyo para la aplicación de técnicas silvícolas especiales acordes al principio de la sostenibilidad. Se conoce por ejemplo sobre las propiedades de los suelos y cómo éstas son modificadas por el manejo forestal, por ejemplo, durante la extracción

(Greacen y Sands, 1980; Froehlich y McNabb, 1984; Gómez y Oleschko, 1994); por las cantidades de biomasa removidas (Boyle *et al.*, 1973; Freedman *et al.*, 1981; Johnson *et al.*, 1982) y las técnicas empleadas en la preparación del terreno (Perry y Rose, 1989; Powers, 1989; Harvey *et al.*, 1989).

Por otro lado, existe una gran cantidad de información relacionada con la importancia de la rizósfera del suelo (Perry *et al.*, 1989) y estudios a nivel microcuenca que han proporcionado información valiosa del flujo de nutrientes (Likens *et al.*, 1977; Johnson *et al.*, 1988; Figueroa, 1975).

Sin embargo, se ha dado poca atención a la función del suelo en la productividad de otros valores. Por ejemplo, se conoce poco el papel que juega el sostobosque en el ciclo de nutrientes y su relación con los microorganismos del suelo (Binkley *et al.*, 1982; SAF, *op. cit.*). De acuerdo con la SAF (*op. cit.*) las investigaciones en suelo se deben enfocar a obtener información de los procesos que operan a escalas geográficas más grandes, por períodos de tiempo largos, involucrando a su vez a los eventos naturales y las actividades humanas.

Vegetación

El conocimiento de los aspectos ecofisiológicos y genéticos de la vegetación es de importancia para el manejo científico de los ecosistemas forestales, y éste se ha enfocado principalmente a las especies de interés comercial.

Debemos reconocer que el uso de la vegetación de los ecosistemas forestales responde a intereses antropogénicos, entre los que destacan por su importancia la producción de madera, creación de hábitat para la fauna silvestre y recreación. Desde este punto de vista, la diversidad ecológica es esencial para los ecosistemas forestales. La posición de algunos científicos con respecto a la estabilidad de los ecosistemas puede interpretarse en función de la biodiversidad, al establecer que los sistemas diversos son más estables que los menos diversos (Maser, 1988). Sin embargo, ante la incertidumbre ambiental (i.e. cambios climáticos, contaminación, reducción de la capa de ozono), lo más prudente es la reducción del riesgo a través del mantenimiento de la diversidad biológica (Velázquez, 1992).

Los hallazgos de los últimos años en relación al funcionamiento de los ecosistemas forestales, han demostrado la importancia de la diversidad ecológica para hacer posible la sostenibilidad, destacando la importancia del reciclaje de raíces y micorrizas y de la fijación biológica del nitrógeno (Cornaby y Waide, 1973; Sharpe y Milbank, 1973). En este sentido, el manejo de la vegetación pionera con habilidad para fijar el nitrógeno atmosférico, es actualmente recomendable para retener la resiliencia de los ecosistemas (Franklin, 1989).

Por otro lado, el conocimiento de la genética de las especies comerciales es avanzado, de tal suerte que es posible inferir el comportamiento posible de especies no comerciales, pero que componen al ecosistema (Dorman, 1976). No obstante, se desconoce bastante la genética de muchas especies, dificultando la predicción del comportamiento de éstas ante posibles cambios en el manejo (SAF, *op. cit.*).

Procesos del ecosistema

El conocimiento de los diferentes procesos en los ecosistemas forestales (i.e. dinámica de nutrientes, relaciones hídricas, distribución de biomasa y flujo de energía) es amplio (Waring y Schlesinger, 1985; Aber y Melillo, 1991). Este tipo de investigaciones, debe insoslayablemente realizarse en donde se aplica el manejo intensivo, de tal suerte que se tengan las bases para realizar la toma de decisiones con mayor certidumbre (Waring y Schlesinger, 1985).

Los procesos sociales, políticos y económicos

La sostenibilidad carece de sentido cuando se pierde su dimensión antropocéntrica. Su interés fundamental se centra en satisfacer las necesidades de bienes y servicios de una sociedad determinada, preservando el ambiente, dentro de un marco legal y político dado, de usos y costumbres socialmente aceptadas.

La sostenibilidad representa una alternativa política en el cómo hacer las cosas, sobre todo, pensando que las nuevas políticas de explotación de los recursos naturales deberán ser capaces de lograr esquemas de continuidad y estabilidad. Continuidad para garantizar que los planes y

programas no dependan de un lapso finito entre la transferencia del poder o de la existencia o no de instituciones responsables, sobre todo en lo referente a la investigación y a los programas sociales de desarrollo (i.e. programas demográficos, apoyos al sector primario, incentivos fiscales para quienes inviertan en la conservación de recursos, etc.).

La estabilidad se concibe generalmente como una consecuencia social, necesaria para el proceso de continuidad de políticas. Las políticas mal enfocadas o con poco o nulo apoyo técnico-científico, desembocan siempre en procesos de inestabilidad social en el mediano o largo plazos. La sociedad ya no está en posición de aceptar políticas que no se diseñen rigurosamente con bases científicas y técnicas y que de acuerdo con los preceptos básicos de la sostenibilidad redunden en beneficio colectivo.

El marco legal en el que se desarrollen las líneas de acción de las instituciones debe representar, como siempre, el consenso de una sociedad en el cómo hacer. De aquí que la ley puede fungir como instrumento de política. Un instrumento muy útil, y el más peligroso cuando no se miden las consecuencias de la acción extrema de la ley por una sociedad o grupo de individuos. La sostenibilidad requiere para su acción la presencia, quizá de muchas leyes, quizá de pocas; esto dependerá de la sociedad y de sus necesidades y complejidad, pero forzozamente requiere de coordinación de cada una de las leyes y órganos involucrados en el manejo de los recursos naturales. Es la sociedad en su conjunto, la que determina los alcances de las leyes y el tipo de políticas emanadas dentro del marco legal.

Económicamente, y en respuesta a los procesos de globalización de la economía, no es posible establecer reglas unilaterales. El beneficio económico no es aceptable si para ello se recurre a la destrucción de un recurso por su falta de utilización o ante las vicisitudes del mercado internacional. Esto, además de afectar los procesos sociales de estabilidad, tiene consecuencias globales. Si nos remitimos a la teoría del caos, no nos es posible determinar el límite de las acciones realizadas hasta que no consideremos un nivel de escala al cual referirlo; un gran conjunto de pequeños caos representa cambios drásticos a gran escala. Se debe lograr la participación del recurso de forma tangible en la economía, ya que es la única forma segura de garantizar su existencia y preservación en el largo plazo.

Tecnología

Dentro del esquema del manejo sostenible, la tecnología juega un papel vital. La capacidad de diseño de las estrategias dependerá en buena medida de los medios con los que se cuente para la explotación y conservación de los ecosistemas. No obstante, el uso de un tipo determinado de tecnología depende en gran medida de las estrategias sociales de manejo y los factores externos que determinan de uso. Así, tecnologías altamente eficientes para la explotación, pueden no ser socialmente aceptadas ante el desplazamiento que ellas ocasionan de mano de obra o por los cambios drásticos que ellas producen en términos de paisaje. La tecnología es el medio para llevar a cabo el manejo sostenible, y esto debe quedar claro, ya que el éxito o fracaso de un determinado paquete tecnológico depende de la aceptación de la sociedad en su implementación, debiendo considerar las barreras culturales y económicas que pueden menguar su utilidad.

ESTRATEGIAS PARA EL MANEJO SOSTENIBLE DE LOS RECURSOS FORESTALES

El nivel de conocimiento logrado permite proponer acciones para, en la práctica, tener un "bosque sostenible" en lugar de un "rendimiento sostenido" (Gordon, 1993). De hecho algunos autores se han referido a los métodos de aprovechamiento coetáneos como una práctica donde no se aplica el principio de sostenibilidad, especialmente en bosques de viejo crecimiento (Maser, 1988).

Considerando al ser humano como parte integral de sistemas biofísicos y ecológicos y que éste está influenciado e influencia a estos sistemas en múltiples escalas (Allen y Hoekstra, 1992), se han planteado cambios en la filosofía del manejo de los recursos forestales, que no solamente se consideran necesarios, sino inevitables.

En la actualidad, la humanidad necesita y demanda un amplio arreglo de recursos, valores y servicios de los ecosistemas forestales (Overbay,

1992). A fin de tener un bosque sostenible, todos los aspectos del manejo deben integrarse en planes basados en principios ecológicos viables (Miller, 1989). El manejo sostenible reconoce que un ecosistema forestal biológicamente diverso es mejor para resistir catástrofes y acciones del hombre, aparte de proveer hábitats diversos para especies vegetales y animales.

Recientemente se ha propuesto el concepto de "Manejo de Ecosistemas" que busca combinar las necesidades y valores sociales, físicos, económicos y biológicos que garanticen ecosistemas sanos y productivos (Kaufmann et al., 1994). El manejo de ecosistemas tiende a la sostenibilidad, ya que trata a los bosques como un sistema jerárquico de organismos y componentes abióticos con enlaces funcionales entre ellos (Allen y Hoekstra, *op. cit.*).

El manejo de ecosistemas intenta mantener intactos complejos procesos, ciclos, interdependencias y funciones de los ecosistemas forestales por largos períodos de tiempo (SAF, *op. cit.*). Los elementos clave incluidos son: mantenimiento de la diversidad biológica y fertilidad del suelo; conservación de la variación genética y su dispersión y, a través de la evolución, la diversidad biológica futura (Perry, 1988; Riggs, 1990).

La diferencia básica entre el manejo tradicional para obtener rendimiento sostenido y el manejo de ecosistemas, estriba en que el primero postula un flujo de productos, con el enfoque de maximizar o enfatizar el rendimiento de intereses dentro de restricciones impuestas por otros usos o por restricciones ambientales o económicas, mientras que el manejo de ecosistemas propone la condición de ecosistema para todos los beneficios y valores que éste ofrece, con el enfoque de retener todas sus funciones y procesos (SAF, *op. cit.*).

El enfoque del manejo de ecosistemas es sin duda un sistema difícil y caro que conlleva a analizar su posibilidad de uso y sus probables efectos. Pero sin duda, el concepto se considera como una alternativa única para dar inicio a resolver la necesidad paradójica de manejar la naturaleza y, al mismo tiempo, generar satisfactores para la sociedad, ya que tiene una base conceptual sólida derivada de la ecología de ecosistemas y del manejo forestal práctico (SAF, op. cit.).

CONSIDERACIONES FINALES

A lo largo de la discusión podemos apreciar cómo los principios expuestos son producto del análisis de conceptos desarrollados en países del primer mundo. La pregunta obligada para nuestro caso es: ¿Será posible aplicar el concepto de manejo sostenible de los ecosistemas forestales en México?, ¿O será posible poner en práctica el manejo sostenible? El conocimiento científico generado en experiencias nacionales se caracteriza por un retraso significativo en cuanto a los avances del primer mundo, lo que se traduce en un desconocimiento del impacto que tiene la producción forestal desde el punto de vista ecológico, ambiental, social y económico (Del Amo y Ramos, *op. cit.*).

No obstante, y partiendo del hecho de que la aplicación de los principios emanados del desarrollo científico y tecnológico son universales, se considera al desarrollo sostenible como la mejor alternativa de solución a futuro.

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Sostenibilidad: ¿Cuanto?

Hugo Ramírez Maldonado[1]

Resumen.—Los conceptos implicados por el término "sostenibilidad" siempre, desde que fueron concebidas, han estado vigentes en las técnicas dasonómicas. Ahora, la sociedad entera se ha sumado a aquellos vinculados con las ciencias, técnicas y producción forestales, en el interés de lograr la sostenibilidad de los recursos, lo que ha enriquecido de manera multidisciplinaria los esfuerzos por lograrlo. Se propone que, sin ser restrictivos de otras conceptualizaciones, los motivos de conservación sean: a) La generación de satisfactores humanos, b) La biodiversidad, c) Los suelos y estratos subyacentes, d) La atmósfera y el aire, e) El agua, f) El clima y los flujos de energía, y g) Las interacciones de los anteriores. Una interrogante crucial es definir el estado en que deseamos sostener esos fenómenos ¿cómo son ahora o cómo fueron hace años?; necesariamente será una convención, con el mejor conocimiento disponible, de cuales serán los paradigmas de la sostenibilidad. En todo caso, cualquier convención deberá ser económicamente rentable, ecológicamente sostenible y socialmente aceptable. La demanda de la sostenibilidad procede del hombre, en tres niveles: La humanidad para su habitat (biosfera), la humanidad para sus organizaciones (la sociedad) y la humanidad para sus integrantes (el humano individual), aunque la proposición parezca indebidamente a tropocéntrica, un análisis evidencia tal origen; una proposición de sostenibilidad debe lograr la congruencia en esos tres niveles. Ahora resulta urgente la definición de descriptores de la sostenibilidad que sean cuantificables, aunque se reconoce un conocimiento limitado para establecerlos, lo que implicaría su revisión constante, sin ello la sostenibilidad seguirá siendo una intensión difusa, motivo de elocuentes debates, pero sin la posibilidad ofrecer normas conductuales para el desarrollo.

INTRODUCCIÓN

La sostenibilidad es un término ineludible en la actualidad, si se pretende dar viabilidad a cualquier proposición. Con relación al manejo de los recursos forestales, hoy se habla de dasonomía sostenible, multifuncional, o con otros adjetivos. Sin embargo al revisar los conceptos contenidos en los textos clásicos de la materia, particularmente los alemanes aun del siglo pasado, se evidencia que la sostenibilidad ha sido una intención intrínseca al término sin adjetivos, traducido indistintamente como "dasonomía" o "forestería" en español, "forestry" en inglés, o "forstwirtschaft" en alemán como en aquellos textos. La sostenibilidad, entonces, no es una innovación para esos profesionales, por lo que autores como Mulder (1991), prefieren hablar solamente de dasonomía, o de silvicultura.

A pesar de lo señalado, ahora es imprescindible tratar de la dasonomía sostenible, ubicados en las corrientes actuales. Este reencuentro con la intención ha resultado benéfico, porque la demanda de mercado, llamada "desarrollo", llevó a la práctica forestal a posiciones extremadamente

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productivistas, que aunque no han sido las más destructivas, si desvirtuaron la naturaleza original de la administración de los recursos forestales. Es benéfico porque ahora nos permite contar como aliados para ese propósito a toda la sociedad. También es positivo porque ahora nos obliga a intentar la cuantificación de la sostenibilidad.

El tema es abordado hoy por un sinnúmero de estudiosos de disciplinas diversas. Esto se justifica porque se trata de un enorme reto sólo comparable en su dimensión con la gran oportunidad de lograr aportes sustantivos, que trascienden no solo las individualidades y a su tiempo, sino aun a sociedades enteras y a sus generaciones. La dimensión del reto alcanza la misma existencia de la especie humana y su desarrollo como hoy los conocemos.

EL CONCEPTO

El concepto de "sostenibilidad" conlleva la existencia de relaciones, objetos o actividades que poseen ese atributo. Para el caso de la administración de recursos forestales cabe entonces preguntarse ¿qué es lo que la dasonomía debería sostener? Tal vez lo podríamos incluir en los siguientes rubros, sin pretender que sean excluyentes o que la esquematización sea única o indiscutible:

- La generación de satisfactores humanos.
- La biodiversidad.
- Los suelos y estratos subyacentes.
- La atmósfera y el aire.
- El agua.
- El clima.y los flujos de energía.
- Las interrelaciones de los anteriores.

Téngase en cuenta que no es posible considerar uno de los rubros señalados sin implicar la existencia de los otros. Obviamente, como ya es del dominio común, esos rubros son integrados en el concepto de ecosistema; sin embargo, para motivos de discusión y análisis es conveniente acercarse a cada una de las fracciones sin perder la noción holística que permite la visión integralista necesaria para lograr interpretaciones válidas.

Pudieramos aceptar que ya sabemos, o intuimos en un grado aceptable, que es lo que deseamos sostener. Cabe ahora interrogarse en que estado debemos mantenerlo. La discusión no es trivial. El estado actual de los rubros señalados arriba no es el mismo que tenían hace algunos años, décadas o siglos. Por ejemplo, algunos de los encinares del Estado de México son producto de la sucesión vegetal ante el aprovechamiento de los pinos. ¿Debiéramos preocuparnos por que esos terrenos prevalezcan en lo sucesivo cubiertos por fagaceas como vegetación arbórea dominante, cuando sabemos que hace 50 años eran pinaceas los árboles dominantes? Tal vez intentáramos convencer de la necesidad de retornar a esas áreas la vegetación de hace 50 años, pero ¿eran los pinos los árboles dominantes hace 100 o 500 años? Otra situación, aún más polémica, la representan los terrenos de cultivo o las plantaciones forestales. ¿Qué se puede argumentar respecto a las presas de contención de agua para riego o producción de energía eléctrica, y los terrenos irrigados?

Lo anterior evidencia que no es posible fijar objetivamente un paradigma o referente del estado en que debemos y deseamos conservar los recursos. Desde la perspectiva del que escribe, no será sino una convención, con el mejor conocimiento disponible, la que nos permitirá establecer los referentes de sostenibilidad.

Ahora bien, el desarrollo de la humanidad ha estado indefectiblemente ligado a la manipulación de la naturaleza por el hombre. Esto nos confronta con el dilema de "desarrollo versus sostenibilidad" (Ulluawishewa 1991). Aquí conviene recordar la forma, a mi juicio incorrecta, en que se ha abordado el análisis de actividades humanas productivas poco desarrolladas, a las que se les ha atribuido la caractrística de sustentables, por ejemplo el caso de la "roza, tumba, quema" practicada en el sureste de México por las culturas mayas. Si bien es cierto que su impacto ecológico puede ser menor que el de otras prácticas llamadas «productivistas», también es cierto que no resultaron sustentables puesto que han sido alteradas o francamente abandonadas por la ganaderización u otras actividades con mayor rentabilidad económica. Se arguye que son errores humanos los que están empujando esos deterioros, pero cabría preguntarse entonces si el hombre mismo y las manifestaciones de su cultura no son

partes integrantes del ecosistema. Algunos autores (MacDonald, 1991) califican como una máscara al llamado «desarrollo», pero ante la evidencia reciente, ¿la humanidad ha sido capaz de frenar la destrucción de los bosques tropicales o de no incrementar la emisión de carbono a la atmósfera? Una proposición que no sea social y económicamente viable, tampoco será sustentable.

¿QUIEN DEMANDA LA SOSTENIBILIDAD?

Hoy, la sostenibilidad es un reclamo de todos, pero también se ha dicho que lo que es de todos no es de nadie, a menos que exista una organización superior a la que hasta ahora han alcanzado nuestras sociedades. La sustentabilidad debe responder a demandantes claramente identificados. En ese intento, tal vez podemos señalar tres demandantes básicos:

- La humanidad para su habitát (la biosfera).
- La humanidad para su organización (la sociedad).
- La humanidad para sus integrantes (el humano individual).

Estos argumentos son recontextuados de otros autores como Giampietro y Bukkens (1992). La diferencia en el enfoque es la omnipresencia del hombre, puesto que no podemos hablar, por ejemplo de los "derechos de la naturaleza" sin que nos autoerijamos como intérpretes de ella y sus voceros, en cuyo caso será nuevamente el derecho del hombre, genérico, el que prevalezca. Esta interpretación pudiera parecer arrogante y antropocéntrica, más sin embargo, ¿no es la humanidad misma la que establece y lucha por los derechos de los animales, por ejemplo? El problema es entonces proponer y convencer a la humanidad de que es lo que a ella mas conviene, en esos términos, la sostenibilidad es una demanda de la humanidad en última instancia, al margen de las teorías creacionistas.

De los tres demandantes apuntados, el primero ha logrado una voz reconocida, aunque no suficiente. En la "Cumbre de la Tierra", en Rio de Janeiro, fue posible escuchar el estado actual de la demandas de la humanidad para su habitát, aunque no fue posible lograr acuerdos unánimes, se tienen avances que ya nos dejan identificar la contradicciones actuales: la demanda de la humanidad para su habitát contra la demanda de la humanidad para sus organizaciones, esto es, la oposición de algunos países a comprometerse con la reducción de emisiones de carbono fósil a la atmósfera y con la conservación de la biodiversidad, al menos en los términos en que fueron redactados los textos que algunos gobiernos reusaron firmar.

El segundo demandante también ha emitido sus anhelos. En las sociedades, particularmente las más desarrolladas, la preocupación por la sostenibilidad hace presencia, al menos declarativa, en todos los ámbitos; aun en paises en desarrollo, Costa Rica por ejemplo, ya ha incluido esa intención como principio nacional. A pesar de la expuesto, nuevamente surgen contradicciones. Se asientan responsabilidades insatisfechas entre una sociedad y otra, y entre una sociedad y sus integrantes. Los ejemplos no son escasos; me parece suficiente recordar que las políticas de préstamos internacionales, del Banco Mundial por ejemplo, condicionan los fondos para el desarrollo a la satisfacción de diversas restricciones respecto a la conservación del ambiente. Estas restricciones, generalmente aceptadas por los países acredores, son entonces conducidas a los integrantes de las naciones, la humanidad en sus individualidades, por medio de legislaciones ambientalistas y como en México, por la adecuación de leyes relativas al uso de los recursos forestales.

El tercer demandante, que por cierto es quien tiene contacto directo con los recursos y por tanto es quien hace o deja de hacer la sustentabilidad, reclama derechos ambientales para él y para sus descendientes. Derechos ambientales para la sostenibilidad y derechos ambientales para el desarrollo. Nuevamente, las controversias no se hacen esperar, el habitante urbano reclama la conservación de las áreas rurales, en tanto que el habitante rural espera beneficios de los recursos naturales de su entorno, sobre todo los mas pobres, demandan derechos ambientales, en algunos casos ya no para el desarrollo, sino para su mera sobrevivencia.

A nivel de congregación humana rural, se han hecho recomendaciones en el sentido de establecer clara y legalmente el ambiente, mejor aun, el ecosistema que debe cuidar, proteger, mejorar y

usar (Agarwal y Narair, 1992). Tales proposiciones van acompañadas de la necesidad de que tengan acceso a los recursos para esa responsabilidad. A nivel países también se han asimilado proposiciones similares, mas aun, llevadas a traducciones económicas como el principio de que "el que contamina paga".

El gran problema para instrumentar lo dicho, estriba en las delimitaciones de los derechos y las obligaciones en los tres niveles de demandantes. Aunque sobre los conceptos implicados la discusión sea cada vez mas armónica, el problema vigente es la cuantificación de la sostenibilidad de los rubros mencionados en el capítulo de El Concepto.

LAS ACTIVIDADES PRODUCTIVAS FORESTALES CON RESPECTO A LA SOSTENIBILIDAD

Como se expresó antes en este escrito, uno de los rubros en los que estamos obligados a la sostenibilidad, es la generación de satisfactores provenientes de los recursos naturales, en este caso de los forestales. Hasta ahora, en base al mejor conocimiento disponible, es evidente que nuestras sociedades no son capaces de renunciar a la obtención de productos forestales. Aun cuando cada día aparecen substitutos de la madera para diversos fines, como laminados por mencionar alguno, no se vislumbra cercano el día en que podamos prescindir del papel por ejemplo.

Si bien es cierto, a mi juicio, que desde sus orígenes la dasonomía ha propendido a la sostenibilidad, también es cierto que esta nueva visita a los conceptos y a las prácticas nos obliga a replantear los problemas en un contexto actualizado. La sostenibilidad no implica el regreso a las formas de cultivo que con una población bastante menor a la actual se ejercían en tiempos pasados. No puede implicarlo porque las demandas de productos, obviamente, se han incrementado y no pueden ser satisfechas con niveles de productividad menores a los actuales. Además, aquellos adversos a ultranza a los modos consumistas olvidan que el consumo es el motor del desarrollo económico, ahora revaluado por la pujanza del mercado libre. No pretendo insinuar siquiera que el consumismo sea el modo deseable, sólo pretendo aseverar que es una realidad innegable.

En la agricultura, que naturalmente también se enarbola ahora con intenciones sostenibles, no se niega la necesidad de continuar cultivando con niveles de productividad elevados. No es posible siquiera suponer que la colecta marginal de esquilmos de la vegetación espontánea sea capaz de ofrecer los alimentos que la humanidad demanda.

Es necesario cuantificar las demandas de productos forestales y encontrar la manera en que serán satisfechas en el futuro previsible. En ese intento, me aventuro a expresar que el aprovechamiento de los bosques naturales, y me refiero a México particularmente, no será una fuente suficiente para satisfacer esas necesidades. No será suficiente por motivos de productividad natural o por motivos de mercado, tengamos presente que actualmente sólo se aprovecha una tercera parte del potencial productivo identificado de nuestros bosques naturales, pero que las importaciones han crecido en los últimos años. Será preciso recurrir a las plantaciones para lograr la producción necesaria. Otros, podrían pensar que las importaciones son positivas en tanto que evitan que se corten árboles en nuestro territorio, tal forma de análisis solo evidenciaría desconocimiento de la realidad.

Resulta muy riesgoso proponer generalizaciones en cuanto a los criterios que deben considerarse para evaluar la sostenibilidad de los recursos forestales. No es conveniente asimilar a todos los terrenos forestales en una sola categoría y en ella basar un solo conjunto de descriptores de la sostenibilidad. Los terrenos ya están diferenciados en cuanto a su uso, sin que se pueda asegurar que ese uso sea el mas adecuado. Es preciso que las definiciones de uso sean llevadas a la práctica. En México, desde la versión anterior de la Ley Forestal ya se prescribían los "usos, destinos y reservas" de los terrenos forestales. Sin embargo, esas prescripciones sólo fueron plasmadas en el papel, pero no ha sido posible llevarlas a la práctica. Uno de los problemas que se han confrontado es la tradición paternalista que ha acompañado al aprovechamiento forestal. Se ha esperado que sea el estado el que establezca, de hecho limitando en el terreno, los suelos que

pueden ser dedicados a un uso u otro, esta intención se pretendió llevar a la realidad en el Estado de México a través del Segundo Estudio Dasonómico, pero la disponibilidad de recursos del gobierno, o su jerarquización de inversión, ha dejado inconcluso el estudio citado. Es conveniente que la regulación se mantenga por el gobierno, como representante de la sociedad en su conjunto, pero las realizaciones deben ser llevadas por los propietarios de los terrenos, por supuesto, también se necesita que ellos dispongan de los recursos para hacerlo.

Habrán de encontrarse otros problemas, por ejemplo el minifundio y la tierra como única fuente de sustento para algunos poseedores de los recursos. Pareciera que las modificaciones al Artículo 27° de la Constitución de México apunta a resolver ciertos problemas, pero hará surgir otros; para la sostenibilidad creo que las modificaciones son conducentes, aunque al mismo tiempo se crean otros problemas, tal es el caso de la emigración a zonas urbanas de poseedores de terrenos que se verán obligados a enajenar sus parcelas, con todo y que los bosques no son sujeto de parcelación, lo que a su vez origina un problema adicional para la conservación: si sólo los terrenos no arbolados son susceptibles de apropiación plena, el árbol es un impedimeto para ese propósito, por lo que será eliminado.

En la agricultura se ha propuesto como criterio para evaluar la sostenibilidad, el mantenimiento de la fertilidad del suelo. Naturalmente, puesto que la biodiversidad es reducida al extremo, mas aun, en la parcela misma se trabaja para evitarla. Tal será el caso de las plantaciones forestales. Sin duda, fuera deseable mantener y mejor aun restablecer la biodiversidad de los terrenos forestales degradados, pero con el conocimiento disponible no es posible lograr los rendimientos que los justifique como una actividad sostenible económicamente. Esos terrenos degradados son dedicados a actividades económicamente marginales, como el pastoreo extensivo que se convierte excesivo, usualmente asociado al hecho de que esa servidumbre es derecho de todos quienes lo han practicado, otra vez, lo que es de todos no es de nadie. La vegetación que en ellos precariamente prevalece, está presente por ser pionera en la sucesión vegetal, o por poder resistir el acoso del pastoreo y los incendios. Así, sería inapropiado considerar la sostenibilidad de la biodiversidad, que en ellos es tan escasa y además antropogénicamente inducida. En esos casos pareciera aconsejable emplear, como en la agricultura (Robison y Dalrymple, 1989), la fertilidad del suelo, empleando mediciones de la disponibilidad de los macronutrientes, además de los micronutrientes identificados como críticos por el cultivo establecido y por las propiedades iniciales de los suelos; por supuesto, al respecto existen evidencias de que los cultivos y su manipulación apropiados pueden incrementar la presencia de algunos nutrientes.

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Conceptos, criterios e indicadores para monitorear la sostenibilidad

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Resumen.—La biósfera provee tres servicios básicos a los seres humanos: producción de recursos naturales, la asimilación de desperdicios y servicios ambientales. El paradigma del desarrollo económico existente está sobrecargando la capacidad de la biósfera para atender estos servicios al no reconocer la magnitud de los efectos negativos de nuestras actividades sobre el medio ambiente. La sostenibilidad se alcanza cuando nuestras actividades económicas no exceden los niveles establecidos para la capacidad de servicio de la biósfera. Los programas de monitoreo nos ayudan a determinar si y/o cuando nuestras actividades económicas exceden los niveles establecidos para la capacidad de la biósfera. Cuatro indicadores ambientales para los recursos naturales incluyen: indicadores de respuesta, indicadores de exposición, indicadores de habitat, e indicadores de estrés. Tanto los indicadores como los criterios para su selección son esenciales en el desarrollo de un programa de monitoreo ambiental.

El medio ambiente natural o la biósfera proveen tres funciones principales para las actividades económicas del ser humano (Jacobs 1991). Primero, nos proveen con tres tipos principales de recursos naturales: recursos no renovables—como carbón, petróleo, gas natural, minerales y otros materiales; recursos renovables—como agua, aire, plantas y animales; y recursos inagotables—como la energía del sol, la cual es usada por organismos fotosintetizadores. Segundo, la biósfera asimila los productos de desperdicio de las actividades humanas y naturales mediante procesos como la captura de carbono, el ciclo de nitrógeno en los ecosistemas forestales, y la filtración y purificación de agua. Tercero, la biósfera nos provee ciertos servicios ambientales. Algunos de estos servicios son tradicionalmente ignorados en los análisis económicos por no tener un valor directo de mercado. Uno de estos servicios, consiste de las amenidades que directa y conscientemente consumimos, como los espacios abiertos para recreación y paisajes, y el habitat para la vida silvestre. El sostenimiento de la vida como el regulamiento del clima y la composición gaseosa de la atmósfera de la tierra, o el mantenimiento de la diversidad genética, que son esenciales para el funcionamiento de la biósfera, pueden ser considerados como otro tipo de servicio ambiental (Jacobs 1991). Sin estas funciones ambientales ninguna actividad económica sería posible.

Podemos decir que muchos de los problemas ambientales que están presionando a la sociedad, son fundamentalmente de naturaleza ecológica (Lubchenco y otros 1991). La creciente población humana y el creciente y mal uso que hace de los recursos, ejerce una presión monumental sobre la capacidad de sostenimiento de la vida de la Tierra. Debemos desarrollar el conocimiento necesario para conservar y manejar los recursos naturales de la Tierra. Todos nosotros—incluyendo el ciudadano común, hacedores de política pública,

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administradores de recursos y líderes de la industria y el comercio, tomamos decisiones con respecto a los recursos de la Tierra, pero éstas decisiones no son efectivas sin un entendimiento fundamental de la forma en que nuestras actividades afectan la biósfera terrestre. El establecimiento de metas u objetivos específicos para las capacidades de la biósfera y el asegurar que nuestras actividades económicas no los excedan, harán posible la sostenibilidad. Está claro que estas metas u objetivos no pueden ser valores absolutos; estos valores cambiarán dependiendo de las condiciones ambientales y si los procesos naturales se están manteniendo, aumentando o reduciendo. Un programa de monitoreo nos permitiría determinar si estamos cumpliendo con los niveles establecidos.

En este trabajo discutiremos los conceptos de monitoreo, indicadores de y salud ambiental y de sostenibilidad y cómo estos se relacionan con el desarrollo económico. También discutiremos la implicación del presente paradigma económico en la sostenibilidad de las biosfera.

SOSTENIBILIDAD Y SALUD AMBIENTAL

La salud y sostenibilidad del medio ambiente natural o de los ecosistemas son bien importantes, no sólo para el bienestar de la humanidad sino de la naturaleza misma. Sin embargo, tanto el concepto de "salud del ecosistema" y "sostenibilidad del ecosistema" son difíciles de definir y mucho más difíciles de hacer operativos. Se han escrito muchos artículos y libros sobre el tema, sin embargo, muchos investigadores no están de acuerdo en el significado de estos términos, o aún en como medirlos o monitorearlos (Gale y Cordroy 1991, Hunsacker y Carpenter 1990, Kelly y Hardwell 1990, Kessler y otros 1992, Lubchenco y otros 1991, SAF 1993, Schaeffer y otros 1988, Schreckenberg y Hadley 1991, Udo de Haes y otros 1991).

Schaeffer y otros (1988) dicen que "...La evaluación de la salud del ecosistema requiere la identificación sistemática de una serie de relaciones que proveerán las bases para organizar información de varias disciplinas... Los objetivos son, la definición inicial de un estado saludable, la selección de parámetros que permitan la cuantificación del estado o condición y la identificación de criterios que permitan la evaluación de la salud relativa."

Según describen Schaeffer y otros (1988) ningún parámetro por si solo tiene suficiente poder de diagnóstico para indicar la salud o estado de un ecosistema. El costo adicional de múltiples indicadores para evaluar la salud de los ecosistemas presenta un reto, especialmente en aquellos países en vías de desarrollo con recurso financieros limitados y grandes necesidades sociales.

El concepto de sostenibilidad es igualmente difícil de definir. Generalmente el concepto de sostenibilidad está vinculado a una relación sostenible entre la sociedad y el medio ambiente (Udo de Haes y otros 1991). La Comisión Mundial sobre Desarrollo y Medio Ambiente (1987) va más allá al decir que el presente nivel de desarrollo económico puede sostenerse sólo si la integridad del medio ambiente físico está protegida. Sin embargo existe un problema. El problema estriba en que ésta estabilidad puede alcanzarse a niveles muy pobres en la calidad ya sea de la sociedad (nivel de desarrollo), como en países en vías de desarrollo, o del medio ambiente (calidad ambiental), o como en áreas industriales muy contaminadas. En algunos casos, tanto el desarrollo social como la protección ambiental están amenazados por factores como áreas montañosas erosionadas en países en desarrollo o los anillos de pobreza alrededor de las grandes ciudades de los países industrializados (Udo de Haes y otros 1991). Al definir o medir la sostenibilidad, tenemos que hacer referencia a estándares de calidad tanto para la sociedad como para la integridad ambiental. Tenemos también que definir el equilibrio deseado entre las dos, con respecto al medio ambiente.

La cuestión de la sostenibilidad se complica más por la falta de información científica rigurosa que se pueda aplicar al proceso de toma de decisiones. Esto se demuestra por los pocos trabajos que tratan temas como la capacidad de largo plazo del suelo después de varios ciclos de corta o el efecto acumulativo del manejo del bosque a niveles de actividad a escala de paisaje, región o provincia (Dunster 1992). El énfasis reciente en las prácticas de manejo adaptables, basad en proyectos cooperativos de investigación y manejo, nos

llevarán a un manejo basado en más conocimiento técnico para la sostenibilidad del bosque. En los programas de manejo adaptable, las actividades de manejo se conducen como experimentos para probar hipótesis y desarrollar información para el manejo futuro de los recursos naturales (Swanson y Franklin 1992). Los programas de investigación de manejo adaptable proveen a los investigadores de oportunidades únicas para desarrollar estudios manipulativos a gran escala, y también proveerán a los administradores de los bosques de la información necesaria para el mejor manejo del bosque, para su salud a largo plazo y su sostenibilidad. Hoy más que nunca, el manejo de los recursos naturales requiere de conocimientos sobre los ecosistemas, incluyendo la relación con los valores humanos, las actividades y patrones de uso de los recursos (Kessler y otros 1992).

DESARROLLO SOSTENIDO

Nos podemos hacer una pregunta: "¿Sostenibilidad para qué?" Gale y Cordray (1991) sugieren por lo menos ocho diferentes respuestas a esta pregunta en referencia a la sostenibilidad de los ecosistemas forestales, yendo desde la sostenibilidad de los "Productos Dominantes" y los "Beneficios Humanos" hasta la sostenibilidad "Centrada en los Ecosistemas" y de los "Tipos de Ecosistemas". En realidad la contestación a esta pregunta depende de la relación tan frágil existente entre la sociedad y el medio ambiente. Maini (1990), por ejemplo, sugiere que el desarrollo sostenible es un proceso que opera a través de la utilización de recursos naturales, la dirección de la inversión, la orientación de la estructura institucional y el desarrollo tecnológico, los cuales están en constante cambio para mantener la armonía y mejorar el potencial presente y futuro de la biosfera para satisfacer la necesidades y aspiraciones de la sociedad. Estas definiciones pueden ofrecer un mejor entendimiento de lo que desarrollo sostenible es—¡aunque no necesariamente como alcanzarlo!

Como el desarrollo económico es necesario para satisfacer las necesidades sociales muchos análisis se han concentrado en estos paradigmas de desarrollo económico para resolver nuestros problemas ambientales. Pero hasta ahora, estos paradigmas económicos no reconocen plenamente el efecto negativo de nuestras actividades sobre la biósfera. Uno de los ejemplos modernos más claros de ésto, son las regiones tropicales del mundo (al igual que las regiones templadas lo fueron en siglos pasados). Como dicen Schreckenberg y Hadley (1991) "...el tipo de desarrollo qúe ha tenido lugar en las regiones tropicales durante las últimas décadas ha causado graves problemas ecológicos, tales como la pérdida de la fertilidad del suelo y el empobrecimiento genético, al extremo que grandes extensiones de tierra en el trópico han perdido su uso productivo." En especial, los bosques tropicales no son manejados sino explotados, de la misma forma que las minas de mineral o metales. Los recursos son explotados para el corto plazo, sin considerar la sostenibilidad a largo plazo de los ecosistemas forestales. Esto, sin embargo, no es un problema exclusivo de los países en vía de desarrollo. En Estados Unidos de América, por ejemplo, cada año, neto de la recuparación natural, se pierden más de mil millones de toneladas de suelo—un área equivalente a casi 300,000 hectáreas (Jacobs 1991).

El hecho de que los patrones presentes del desarrollo económico sean dañinos al ambiente, no implica que la solución a nuestros problemas ambientales sea el detener el desarrollo económico. Cero desarrollo económico o una reducción del desarrollo económico, puede resultar igualmente dañino, y en algunos casos peor que el desarrollo económico mismo (Udo de Haes y otros 1991, Jacobs 1991). Necesitamos tener una definición de sostenibilidad que nos permita hacer compatibles la conservación del medio ambiente con el desarrollo económico deseado para satisfacer las necesidades de la sociedad. Usando la definición propuesta por la Comisión Mundial sobre Desarrollo y Medio Ambiente (1987) como punto de partida y como resultado de la necesidad de definir lo que se entiende por protección ambiental Jacobs (1991) propone la siguiente definición operativa: "Sostenibilidad quiere decir que el medio ambiente debe ser protegido en tal condición y a tal nivel que las capacidades del medio ambiente (la habilidad del medio ambiente para llevar a cabo sus varias funciones) se mantienen en el tiempo; por lo menos a niveles suficientes para evitar catástrofes futuros, y a lo más, a niveles que permitan a las generaciones

futuras la oportunidad de disfrutar de un nivel de consumo de servicios ambientales igual al presente."

En el caso de los recursos renovables, mientras la tasa de utilización no exceda la tasa de regeneración, el acervo del recurso se mantiene constante, la capacidad ambiental del recurso se mantiene y por lo tanto, se alcanza la sostenibilidad (Jacobs 1991). Igualmente para la función de asimilación de desperdicios, la regla básica para la sostenibilidad es que la tasa del flujo (y la concentración) de las descargas de desperdicios no excedan la capacidad asimiladora del medio que las recibe. Las medidas de sostenibilidad para la capacidad de servicios ambientales son más difíciles porque los servicios ambientales no son consumidos como los recursos renovables o no renovables.

MONITOREO

El monitorear los indicadores ambientales puede usarse para registrar los cambios en la capacidad ambiental y su consumo (en cuanto se ha disminuído la capacidad ambiental). Teóricamente el adoptar límites o niveles para los indicadores ambientales apropiados y el asegurarnos que las actividades económicas no exceden estos límites, nos permite convertir la sostenibilidad en una política operacional.

El concepto de monitoreo se aplica algunas veces a una serie de actividades bien dispares, casi indiscriminadamente. Por ejemplo, actividades como un intento de describir las condiciones ambientales existentes; la ocurrencia, distribución, e intensidad de la contaminación; o aún el proveer una descripción breve de las condiciones de las áreas rurales se han considerado como monitoreo (Hellawell 1991). El adoptar una definición clara de lo que entendemos por monitoreo nos ayuda a asegurar el diseño de un programa de monitoreo. Hellawell (1991) nos ofrece las siguientes tres definiciones:

- *Encuesta*—Un ejercicio en el cual se realizan una serie de medidas cualitativas y cuantitativas generalmente mediante unos procesos estándares y dentro de un período de tiempo restringido.

- *Vigilancia*—Un programa extendido de encuestas llevado a cabo para desarrollar una serie histórica, averiguar (determinar) la variabilidad y/o rango del estado o valores que se pueden esperar en el tiempo (otra vez, sin tener una preconcepción de los valores que se pueden esperar).

- *Monitoreo*—Una vigilancia intermitente (regular o irregular) realizada para averiguar (determinar) el grado de cumplimiento con un estándard determinado o el grado de desviación de la norma esperada.

La diferencia principal entre la definición de monitoreo de Hellawell y la de vigilancia y encuesta, es que el monitoreo intrínsecamente tiene un propósito y presupone una idea de los resultados esperados. La preocupación es con el establecimiento de límites, no importa cuan arbitrarios, y decidir qué hacer cuando el monitoreo revela que la situación actual está fuera de la norma o límite. Antes de hacer medición o establecer un programa de monitoreo, es importante considerar las siguientes cinco preguntas (Usher 1991, Roberts 1991):

1. Propósito—¿Porqué estamos monitoreando? ¿Cuál es el objetivo del monitoreo? El recopilar datos no es suficiente razón por sí misma. Es necesario especificar el propósito de los datos, es decir, cuál es la pregunta que necesitamos contestar. La intensidad y frecuencia del monitoreo también deben considerarse.

2. Método—¿Cómo podemos alcanzar nuestro objetivo? ¿Cómo podemos obtener los datos? Esto incluye decidir sobre las técnicas de muestreo y cualquier actividad experimental.

3. Análisis—¿Cómo vamos a manejar los datos recabados? ¿Qué datos, pruebas y análisis se necesitan para contestar la pregunta hecha? Esto incluye determinar el tipo de datos necesarios, el tamaño de la muestra y los estas son análisis estadísticos apropiados, si necesarios.

4. Interpretación—¿Qué pueden significar los datos?

5. Cumplimiento—¿Cuándo habremos alcanzado nuestro objetivo?

Tipos de monitoreo

En general hay tres grandes razones para el monitoreo: evaluar la efectividad de las políticas de la o legislación, regulatoria (función de auditoría o ejecución) y la detección de cambios incipientes (aviso temprano) (Hellawell 1991). MacDonald y otros (1991) han definido varios tipos de monitoreo, dependiendo de porque queremos monitorear. Estos tipos de monitoreo no son excluyentes y se definen más por el propósito del monitoreo que por el tipo e intensidad de las mediciones.

- *Monitoreo de tendencia*—Se toman medidas a intervalos de tiempo regulares para determinar la tendencia de largo plazo de un parámetro en particular. Por ejemplo, mediciones de datos climáticos o de agua.

- *Monitoreo base*—También conocido como monitoreo de evaluación o inventario. Este muestreo se usa para caracterizar las condiciones ambientales existentes y para establecer una base de datos para planificar o hacer comparaciones futuras. Algunos ejemplos son el desarrollar inventarios de especies o inventarios de hábitat para la vida silvestre.

- *Monitoreo de efectividad*—Usado para evaluar si las actividades se llevaron a cabo tal y como fueron planeadas. Un ejemplo es hacer visitas de campo para determinar si un proyecto se ejecutó según lo especificado en el contrato o documento de planificación.

- *Monitoreo de efectividad*—Se usa para determinar si las actividades especificas que se implantaron tuvieron el efecto deseado. Un ejemplo es la medición de cambios en la calidad de agua antes y después de implantar las mejores prácticas de manejo, como el establecimiento de zonas de ribereñas amortiguación .

- *Monitoreo de proyectos*—Se usa para evaluar el impacto de una actividad o tipo de proyecto en particular, como un contrato de corta de madera. Puede incluir tanto monitoreo de efectividad, como de implantación.

- *Monitoreo de validación*—Se usa para probar independientemente los resultados de un modelo para proveer una evaluación objetiva de la ejecución completa del modelo.

Cada uno de estos tipos de monitoreo juega un papel en el monitoreo de la sostenibilidad y también tienen sus costos asociados. El monitoreo de base y el de implantación son generalmente los más costo-efectivos, mientras que los monitoreos de efectividad y de validación requieren el mayor rigor y diseño científicos.

INDICADORES PARA LA SOSTENIBILIDAD Y SALUD AMBIENTAL DE LOS BOSQUES

Consideraciones generales

De acuerdo a Jacobs (1991), para medir la sostenibilidad dos tipos de indicadores ambientales necesitan establecer límites: aquellos que miden la cantidad y calidad del acervo de aquellas características ambientales esenciales tales como suelos, bosques, uso de terrenos, recursos hidráulicos (marinos y dulce), y número y diversidad de especies entre otros; y aquellos que miden la actividad económica que causa los cambios en los primeros tipos de indicadores tales como la tasa de descarga y emisión de contaminantes.

Es importante monitorear aquellos indicadores que nos ayudan a evaluar si un ecosistema está en condiciones de sostenibilidad. Aquellos indicadores que proveen información sobre la "salud" y la "vitalidad" de los ecosistemas, deben también indicar la posibilidad de sostenibilidad. El

reconocimiento del potencial de cambio está implícito en la mayoría de las actividades del monitoreo. Queremos detectar si un cambio ha ocurrido, establecer la dirección del mismo y medir su alcanze o intensidad. Es en esta etapa cuando el monitoreo de los indicadores críticos de la salud del ecosistema y la sostenibilidad es importante. Un monitoreo de largo plazo será el más informativo y el que con mayor seguridad detecte señales de deterioro siginificativo en el ecosistema o desviaciones poco usuales de los patrones esperados del estado o funcionamiento del ecosistema.

El desarrollo y uso de indicadores para el monitoreo de la salud de los ecosistemas está todavía evolucionando (Lubchenco y otros 1991, Schaeffer y otros 1988). Sólo existe un número pequeño de herramientas de diagnóstico probadas para evaluar la salud de los ecosistemas (Schaeffer y otros 1988). No existe ningún indicador que por sí solo tenga el valor de diagnóstico suficiente para indicar la salud o estado de un bosque. Se necesita una combinación de indicadores, o en algunos casos, una serie de indicadores para presentar un cuadro claro de la salud y la sostenibilidad de un ecosistema (Kelly and Harwell 1990).

Algunos autores han discutido varios criterios o guías para la selección de indicadores de la salud de los ecosistemas (Hunsaker 1993, Hunsaker and Carpenter 1990, Kelly and Harwell 19990, Riiters y otros 1992). Los indicadores seleccionados para el monitoreo pueden estar determinados en parte por la condición final o las características a sostenerse en el bosque (ej., biodiversidad, madera, recreación y estética, hábitat para la vida silvestre). La ciencia de los ecosistemas ha progresado hasta una etapa donde los principios ecológicos generales y las características de un ecosistema "saludable" se conocen. Basados en este conocimiento podemos desarrollar, emplear y refinar indicadores candidatos para determinar la salud y la sostenibilidad de los bosques. Independientemente de los indicadores finalmente seleccionados, tenemos que asegurarnos de evaluar su respuesta relativa a los patrones sucesionales del desarrollo del bosque. Las siguientes características, por ejemplo, pueden cambiar dramáticamente con la progresión de la sucesión y desarrollo del rodal: tasa de crecimiento del rodal, distribución de biomasa, el ciclo y los acervos de nutrientes, incidencia de enfermedades y brotes de plagas (Grier y otros 1989). La respuesta de indicadores basados en estos procesos o parámetros de los ecosistemas pueden variar dependiendo del estado de desarrollo y sucesión del rodal.

De acuerdo con la Sociedad de Forestales Americanos (SAF 1993), los elementos claves en la sostenibilidad del bosque son el mantenimiento de la diversidad biológica y la fertilidad de los suelos, y la conservación y dispersión de la variación genética. Un grupo de trabajo de la SAF sobre el Sostenimiento de la Salud y Productividad de Largo Plazo del Bosque (SAF 1993) recomendó que el objetivo principal para la sostenibilidad del bosque debe enfocarse en su estado. El acervo (ej., volumen de madera, densidad de vida silvestre, millas de veredas) y los flujos y rendimientos (ej., agua, producción anual de fibra, libras de peces anádromos) deben ser de consideración secundaria. Estas prioridades están basadas en la premisa de que un bosque en su estado funcional saludable está mejor preparado para el mantenimiento y apoyo de valores ambientales múltiples en el largo plazo . Los indicadores de sosteniblidad del bosque deben reflejar el estado del ecosistema tomando la productividad como una medida secundaria de sostenibilidad. Asumiendo que la base de la diversidad genética está intacta, el suelo es el único recurso fundamental para la sostenibilidad del bosque. De acuerdo a Powers (1989), el volumen de suelo, la materia orgánica del mismo y su porosidad total son los factores principales en determinar la productividad potencial del largo plazo de los rodales del bosque.

La interpretación de las respuestas de los indicadores del bosque deben considerarse en el contexto de las prácticas de manejo anteriores, estresores ambientales y climáticos, el uso de la tierra, y la historia del rodal. Por ejemplo, técnicas de corta muy dañinas pueden resultar en la pérdida del mantillo y de la materia orgánica del suelo, la compactación del suelo y la reducción de la porosidad del suelo. La consecuencia directa de esto es una pérdida significativa en la capacidad de un lugar para desarrollar árboles vigorosos y puede también explicar el deterioro en la salud del bosque. Otras consideraciones también importantes en el mantenimiento y monitoreo de la sostenibilidad del bosque son el conocimiento

del régimen natural de fuego, la historia de los incendios en el rodal actual o la exclusión del fuego y sus posibles efectos en la sostenibilidad del bosque. La respuesta de indicadores sugiriendo una disminución en la sostenibilidad del bosque también puede explicarse mediante información adicional con respecto a las prácticas de manejo e historia del rodal, episodios de situaciones climáticas externas o exposición severa a contaminantes.

El desarrollo de indicadores sensitivos con una tasa de señal-de-ruido alta, es uno de los grandes retos en la evaluación de la sostenibilidad y salud del bosque. Los indicadores sensitivos generalmente exhiben una gran variabilidad natural. La falta de indicadores sensitivos para medir el estrés de los ecosistemas limita la detección de las etapas iniciales de cambios ecológicos (Lubchenco y otros 1991). Generalmente la degradación de los ecosistemas se descubre "después que ha sucedido" (análisis retrospectivo). Se necesitan indicadores de estrés o enfermedad inicial que ocurran antes de que los síntomas de la enfermedad alcance niveles clínicos (Kelly y Harwell 1990, Schaeffer y otros 19988). Indicadores a nivel de especies normalmente responden más rápido que indicadores a nivel de proceso. Cambios en las funciones del ecosistema implican efectos previos asociados en la población biótica llevando a cabo esas funciones. Por lo tanto, mediciones de los procesos funcionales de los ecosistemas (indicadores funcionales como productividad y flujo de nutrientes) son típicamente indicadores menos sensitivos al estrés del ecosistema que las propiedades estructurales como la composición de especies (Kelly y Harwell 19990, Lubchenco y otros 1991). Sin embargo, los indicadores funcionales todavía pueden servir como indicadores de las consecuencias de largo plazo, pre-avisando quizá cambios irreversibles (Kelly y Harwell 1990).

Analogía con la salud humana

Rutinariamente los médicos miden la temperatura, la presión sanguínea, las pulsaciones del corazón y el peso de sus pacientes para monitorear su condición física. En el monitoreo de la salud del bosque algunos parámetros similares en árboles individuales pueden ser el crecimiento anual, la tasa de copa viva, el área superficial de las hojas y la retención de las acículas; para un rodal pueden ser el área superficial de las hojas, la diversidad, dominancia y productividad del rodal (Smith 1990). Odum (1985) ha bosquejado las tendencias generales esperadas en ecosistemas estresados en términos energéticos (ej., aumento en la tasa de respiración/producción y una baja eficiencia en convertir la energía en estructura orgánica), ciclo de nutrientes (ej., aumento en la pérdida de nutrientes), y estructura comunitaria (ej., aumento en la proporción de especies oportunísticas, reducción en el tamaño y largo de vida de los organismos). Otras tendencias inesperadas identificadas por Odum (1985) incluyen la reducción en la eficiencia de uso de los recursos, un aumento en el parasitismo y una reducción en el mutualismo, los ecosistemas se convierten en más abiertos a medida que los flujos internos se reducen y una reversión en los procesos sucesionales. Schaeffer y otros (1988) reconocen que en un sentido amplio, algunas patologías de los ecosistemas son conocidas, tales como un aumento en el transporte horizontal de los nutrientes, aumento en la tasa de producción/biomasa y una reducción en la diversidad. La diversidad de especies en un ecosistema, puede también aumentar en respuesta a un estrés, si la diversidad inicial es baja (Odum 1985). Schaeffer y otros (1988) definen a un ecosistema como enfermo, si los efectos de la enfermedad son profundos. Algunos de los efectos profundos o indicadores de ecosistemas enfermos, incluyen cambios: en la biomasa vegetativa presente, netos o brutos en la producción energética primaria, en la cantidad relativa de energía que fluye a las cadenas de descomposición y forraje, en el acervo de macronutrientes minerales, y cambios tanto en el mecanismo de, como en la capacidad para, amortiguar las oscilaciones indeseables. Los ecosistemas enfermos también pueden exhibir una reducción en el número de especies nativas y una sucesión regresiva general.

Categorías de indicadores

El Programa de Evaluación y Monitoreo Ambiental (EMAP) de la Agencia Para la Protección Ambiental (EPA) de Estados Unidos de América reconoce cuatro grandes categorías de

indicadores ambientales para los recursos naturales: indicadores de respuesta, indicadores de exposición, indicadores de hábitat e indicadores de estrés.

Indicadores de respuesta son los primeros barómetros de la condición ecológica y pueden consistir de indicadores a nivel de organismos, poblaciones, comunidades o características de ecosistemas. Algunos ejemplos de indicadores de respuesta para los bosques son la eficiencia en el crecimiento de los árboles, síntomas visuales de daño en el follaje, exportación de nitrógeno, abundancia y composición de las especies del sotobosque o la demografía de animales.

Indicadores de exposición son medidas de la exposición de organismos, poblaciones o ecosistemas a agentes químicos, nutrientes, acidez, calor o estrés físico. Algunos ejemplos de indicadores de exposición, incluyen sistemas visuales de daño en el follaje (también puede ser un indicador de respuesta), nutrientes o contaminantes químicos en el follaje de los árboles (o en musgos o líquenes) y biomarcadores (ej.: actividad inducible de las enzimas en respuesta a la exposición de contaminantes).

Indicadores de hábitat representan condiciones que son necesarias para mantener un organismo, población o comunidad. Algunos ejemplos de estos indicadores son la abundancia y densidad de características físicas claves (ej.: árboles muertos, peñascos, filtraciones, taludes), la extensión y patrón espacial de la cobertura vegetal y las capas verticales de vegetación. El Programa de Monitoreo y Evaluación Ambiental usa los indicadores de hábitat y de respuesta para identificar y cuantificar la exposición y hábitat físico que están asociados con cambios en los indicadores de respuesta.

Los **indicadores de estrés** reflejan aquellos procesos naturales, peligros ambientales, o acciones de manejo que causan estrés a un ecosistema. Algunos ejemplos de indicadores de estrés incluyen medidas de emisión de contaminantes, el número de permisos de construcción, las prácticas de uso de terreno, las condiciones o fluctuaciones climáticas, las brotes de enfermeda des o plagas o los tratamientos silvícolas.

Criterios para la selección de indicadores

La siguiente lista de características deseables de los indicadores para un programa de evaluación ambiental y monitoreo, ha sido delineada por Husaker (1993), Hunsaker y Carpenter (1990) y Schaeffer otros (1988):

- Correlación con cambios en los process u otros componentes no medidos
- Apropiados para monitoreo regional
- Integración de los efectos en el tiempo y en el espacio
- Tienen una variabilidad natural baja
- Directamente relacionados con la salud y sostenibilidad del bosque, una variable de hábitat o exposición, o un estresor
- Relacionardos con la estructura general y funciones del ecosistema
- Uno de varios indicadores que representa colectivamente un conjunto de valores ambientales, pero no es redundante
- Sensitivos a aquellos estresores relevantes para las estrategias de manejo
- Un método estándar y un bajo error de medición
- Una base histórica de datos o datos accesibles par el desarrollo de una base de datos
- Costo-eficiencia (bajo costo/mucha información)
- Reflejan conocimiento de cambios "normales", por ejemplo, debido a la sucesión u otros cambios secuenciales
- Tienen un rango definido de valores "normales" (Schaeffer y otros 1988)
- Tienen una tasa lo suficientemente alta de señal-de-ruido (Kelly y Harwell 1990)

Ejemplos de indicadores de respuesta para la sostenibilidad del bosque

Algunos indicadores que se ha implantado o considerados en alguna que otra medida (Hunsaker y Carpenter 1990) incluyen: la dinámica química de la hojarasca, la respiración y biomasa microbial en el suelo, la reflexión espectral de las hojas, la teledetección, índices los de nutrientes como el DRIS (Sistema Integrado de Diagnóstico y Recomendación, Riiters y otros 1992), la tasa de amino ácidos y nutrientes en el follaje (McLaughlin y otros 1994), la estructura del rodal (composición, diversidad, dominancia), demografía animal y bioensayos (ej., musgos y líquenes).

Eficiencia en el crecimiento de los árboles

La eficiencia en el crecimiento de los árboles refleja la habilidad de los árboles para mantener una presencia saludable y productiva en el ecosistema. La eficiencia en el crecimiento de los árboles, también se relaciona con la sostenibilidad porque niveles de eficiencia de crecimiento más altos están asociados con una mayor resistencia a ataques de insectos (Mitchel y otros 1983). El uso de indicadores de crecimiento está basado en los patrones de distribución del carbón en los árboles. Los estreses ambientales que alteran la distribución de carbón se manifiestan primero en una reducción del crecimiento de la madera del tronco y una reducción en la producción de químicos protectores. Por lo tanto, el crecimiento de la medera del tronco se usa como el indicador (Hunsaker y Carpenter 1990).

La eficiencia del crecimiento se mide como el volumen de crecimiento del tronco ($m^3ha^{-1}yr^{-1}$)o crecimiento de biomasa ($kgha^{-1}año^{-1}$) dividido por la capacidad de crecimiento. El denominador puede ser cualquiera de una serie de índices de la cantidad de luz absorbida por el dosel superior (ej., el índice del área de las hojas (LAI)), o la fracción de la radiación fotosintética activa absorbida por el dosel (APAR). Para poder ser aplicado como un indicador de respuesta, hay que desarrollar los valores iniciales para la eficiencia de crecimiento sub par, posiblemente de la literatura, datos anteriores o mediante investigación y pruebas.

Algunos han sugerido que tanto el numerador como el denominador sean considerados como indicadores separados, debido a que si ambos se reducen en la misma cantidad, el valor de la eficiencia del crecimiento se mantiene constante, aún cuando la productividad y la sostenibilidad han cambiado (Hunsaker y Carpenter 1990). Además, la interpretación de los indicadores de la eficiencia del crecimiento se deben hacer en conjunto con información sobre la composición de las especies, la edad y la densidad del rodal. Las mediciones de la madera del tronco y del follaje se deben hacer después del período de crecimiento rápido entre la primavera y mediados del verano. La frecuencia recomendada para la colección de datos es cada 10 años (Hunsaker y Carpenter 1990). El volumen de la madera del tronco puede hacerse mediante técnicas estándard (Husch y otros 1972). El LAI puede estimarse de datos tomados vía satélite; tanto el LAI y el APAR pueden obtenerse en el campo mediante aparatos manuales (Hunsaker y Carpenter 1990).

Entre los problemas principales con estos indicadores está el obtener medidas de volumen o biomasa lo suficientemente precisas con los procedimientos estándares. Es posible tener que usar procedimientos más precisos, aunque más caros. Los métodos indirectos para estimar el LAI y el APAR también tienen limitaciones. El método más apropiado dependerá de la composición y densidad del rodal, de las características del terreno y de otros factores relacionados.

Síntomas visuales de daño al follaje

Los síntomas visuales de daño al follaje proveen un indicador de respuesta para los valores ambientales de productividad y estética; y pueden indicar estrés de exposición o hábitat que estén afectando la condición del bosque. Utilizar el protocolo internacional para encuestas visuales nos permitiría hacer comparaciones interespecíficas y daría más relevancia a estudios en otras regiones del mundo (Hunsaker y Carpenter 1990). Observaciones de "plantas indicadoras" pueden usarse efectivamente como señales de la exposición del bosque a contaminantes específicos. En los programas de monitoreo, las plantas nativas indicadoras son consideradas como indicadores de

respuesta, ya que son un componente integral del ecosistema forestal, y como un indicador de exposición, porque indica posibles daños a otras especies (Hunsaker y Carpenter 1990). Plantas biomonitoras que son sensitivas y que desarrollan síntomas conocidos a la exposición de contaminantes específicos también pueden usarse como indicadores de exposición (Krupa y otros 1993).

Las medidas básicas de síntomas visuales que más frecuentemente se hacen son: densidad del dosel, transparencia del dosel (medida de la defoliación), tasa de la altura al dosel vivo, clase del dosel, decoloración, muerte del dosel, retención y tamaño de las acículas e identificación de patógenos e insectos. Las muestras que requieran el corte de árboles, deben tomarse fuera del lugar donde están las parcelas permanentes de monitoreo. La identificación de patógenos puede hacerse a través de cultivos de las muestras de las raíces. Los dos problemas principales con los indicadores de daño visual son la estandarización de las medidas y los métodos de evaluación y el adiestramiento de los miembros de las cuadrillas para que hagan una determinación subjetiva consistente de la condición del dosel dentro de un rango del 10 porciento.

Exportación de nitrógeno

La exportación de nitrógeno del ecosistema forestal en forma de nitrato (NO_3^-) tiene potencial como un buen indicador de respuesta porque provee un indicador de respuesta a nivel de la cuenca completa y representa una medida integradora de los varios procesos del flujo de nitrógeno dentro de la cuenca hidrográfica. En ecosistemas perturbados la pérdida de nitrógeno es generalmente mayor que la de otros nutrientes. Aunque las perturbaciones no siempre resultan en una alteración de las pérdidas de NO_3^-, cambios en la exportación de NO_3^- proveen una fuerte indicación de de perturbaciones dentro del ecosistema. Eventos aleatorios como incendios, defoliación por insectos y pastoreo pueden también afectar la concentración de nitratos en las aguas de los ríos (Hunsaker y Carpenter 1990).

Para implantar este indicador, se utilizan procedimientos estándares de laboratorio para analizar la concentración NO_3^- en muestras de agua de escorrentías o de acuíferos. La naturaleza impredecible de la exportación de nitrógeno puede ser un problema de este tipo de indicador pues, hace muy difícil establecer una ventana de oportunidades para el muestreo. Sin embargo, las concentraciones de NO_3^- tienden a ser mayores durante el deshielo de primavera, o cuando la demanda de nitrógeno por las plantas y los microbios es menor. La retención de NO_3^- puede también ser menor en rodales maduros que en rodales jóvenes con mucho mayor vigor de crecimiento.

Índice de productividad del suelo

La productividad del suelo se puede definir como la capacidad de un volumen de suelo de producir una respuesta vegetativa bajo un régimen de manejo específico. Para establecer los niveles básicos y tasas entre los constituyentes físicos, químicos y biológicos del suelo se toman medidas iniciales de variables claves de lá productividad del suelo. Esta caracterización base del suelo se usa para compararla con condiciones nominales y subnominales del bosque, medidas por los indicadores de respuesta (Hunsaker y Carpenter 1990). Una remedición periódica de estos valores de cada cuatro a seis años puede servir para determinar tendencias . Los siguientes parámetros son los comúnmente de más interés: nutrientes específicos del suelo, substancias tóxicas, factores de erosión, características estructurales del suelo, material base y datos relacionados como el abastecimiento de humedad del suelo (ej.,Índice de Sequía de Palmer, Hunsaker y Carpenter 1990).

La datos de productividad del suelo proveen información interpretativa no disponible mediante el análisis químico del follaje porque las plantas pueden compensar por la falta de nutrientes y humedad del suelo. La productividad del bosque puede ser afectada por la deficiencia crónica o aguda de nutrientes esenciales del suelo. El muestreo y caracterizsación del suelo en una parcela determinada debe hacerse concurrente con la medición de los árboles y el muestreo del follaje. Debido a la significativa alta variabilidad espacial que puede ocurrir en una parcela, se recomienda un diseño de colección de muestras compuesto.

RESUMEN

Las tendencias presentes en el desarrollo económico actual, para satisfacer las necesidades y deseos sociales, están en el centro de nuestros problemas ambientales. Hasta hace muy poco, el balance estuvo en favor de un paradigma de desarrollo económico que no tomaba en consideración toda la magnitud de los impactos negativos de nuestras actividades económicas sobre el ambiente natural. Se necesita un nuevo paradigma de desarrollo económico que garantice la sostenibilidad del ambiente natural.

Esta sostenibilidad puede alcanzarce mediante el el monitoreo cuidadoso de indicadores selectivos de la salud del ecositema, asegurando así que nuestras actividades económicas y el manejo del ecosistema no causarán deterioros significativos en la salud y funcionamiento del ecosistema. Sin embargo, el costo de monitoreo de los indicadores de salud ambiental no debe ser excesivo, o la implantación de programas de monitoreo de la salud ambiental será muy difícil, en especial en aquellos países con grandes problemas ambientales y escasos recursos financieros.

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Métodos para monitorear sostenibilidad

Andrew J.R. Gillespie[1]

Resumen.—El manejo sostenible requiere de información confiable. La información puede provenir de varias fuentes. El monitoreo implica un periodo largo, en el que periódicamente se colecta información que ayuda a determinar el estado actual de un sistema, así como los cambios que ocurren a lo largo del tiempo. Esta información se retroalimenta en el proceso de planificación del manejo, permitiendo hacer correcciones para mantener el sistema en un estado sostenible. Este artículo discute varios aspectos del diseño de un sistema para monitorear la sostenibilidad de un ecosistema forestal, incluyendo la definición de los objetivos y las medidas del monitoreo, el diseño del sistema de muestreo, la conducción de actividades para asegurar la calidad, y las mejoras contínuas del sistema de monitoreo a lo largo del tiempo.

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Métodos para evaluar la sostenibilidad en el manejo de bosques: Una perspectiva de México

Gerardo Segura[1]

Resumen.— A pesar de que los recursos forestales ocupan una gran extensión del territorio mexicano y que representan un recurso biológico y económico importante, estos no han podido ser conservados ni manejados sosteniblemente. En la actualidad México tiene una de las tasas de desforestación más altas de Latinoamérica y el sector forestal está atravezando por una severa crisis en donde la producción forestal ha caido en un 30% y las importaciones han aumentado en una proporción similar. Esto se debe en gran medida a que los productos forestales mexicanos no son competitivos con productos más baratos de otros países en el contexto de una economía abierta. Para lograr que el manejo forestal en México sea operativo y poder así desarrollar criterios y métodos eficientes para su evaluación, es indispensable asegurar una serie de condiciones mínimas previas que permitan que los dueños de estos recursos vean en ellos una alternativa económica viable para mejorar sus condiciones de vida. En este artículo se analiza cuales son estas condiciones mínimas necesarias para lograr un manejo sostenible del bosque en relación a tres parámetros generales: equidad, capital natural y eficiencia. El artículo incluye también una discusión de las causas por las que estas condiciones no se han logrado en México.

INTRODUCCIÓN

México tiene cerca de 57 millones de hectáreas de bosques cerrados, de los que el 46% son bosques tropicales y el 54% son bosques templados (coníferas y latifoliadas) (SARH, 1994a). Estos bosques ocupan el 28.9% del territorio nacional y representan un importante recurso biológico y económico. Es en estos tipos de vegetación en donde se concentran el mayor número de especies de flora y fauna silvestre que hacen ser a México uno de los 10 países con mayor biodiversidad biológica del mundo (Toledo, 1988).

A pesar de la importancia de los recursos forestales en México, estos no han podido ser conservados ni manejados sosteniblemente. En la actualidad México tiene una de las tasas de desforestación más altas del Latinoamérica (800,000 ha/año) que está principalmente asociada a cambios de uso de suelo a actividades agrícolas y pecuarias (Masera *et al.* 1992). Por otro lado, los bosques con valor comercial están siendo subaprovechados en relación a su potencial de crecimiento, y salvo un porcentaje relativamente bajo, se explotan sin un programa de manejo autorizado o se aprovechan utilizando sistemas silvícolas inapropiados que no aseguran su sostenibilidad. Esta situación ha provocado que en la mayoría de los casos los bosques no hayan sido capaces de satisfacer las necesidades de subsistencia y mejorar las condiciones de vida de sus pobladores y por consiguiente no representen un recurso alternativo a la agricultura y la ganadería.

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Por otro lado, a raíz de la apertura comercial que ha empezado a ocurrir desde el ingreso de México al GATT y la puesta en vigor del TLC, y como resultado de su incapacidad de competir en los mercados internacionales, el sector forestal mexicano ha entrado en una severa crisis en la que tan solo en los últimos diez años su contribución al PIB ha decaído en un 2.4%, bajando su participación del 0.9 al 0.6% en el PIB real total y del 10.7 al 7.7% en el PIB real del sector agropecuario. La producción anual oficial de madera en rollo disminuyó casi en un 30% (de 8,900 a 6,350 miles de m^3) entre 1989 y 1993 (SARH, 1993) mientras que las importaciones de productos forestales en general incrementaron del 6.1 al 29.9% (de 540 a 1,900 miles de m^3) en el mismo período (SARH, 1994b) (Figura 1).

A pesar de que el valor económico de los bosques y selvas mexicanos se ha reducido con la apertura comercial, los recursos forestales siguen teniendo el potencial de ser una alternativa económica para sus pobladores. Sin embargo, antes de lograr un uso sostenible de los bosques mexicanos es necesario cumplir una serie de condiciones básicas mínimas que además de asegurar la permanencia de beneficios ambientales y valores ecológicos induzcan que el manejo forestal sea una alternativa cada vez más viable desde el punto de vista económico y social, es decir que permita y promueva la subsistencia y el mejoramiento de las condiciones de vida de sus pobladores.

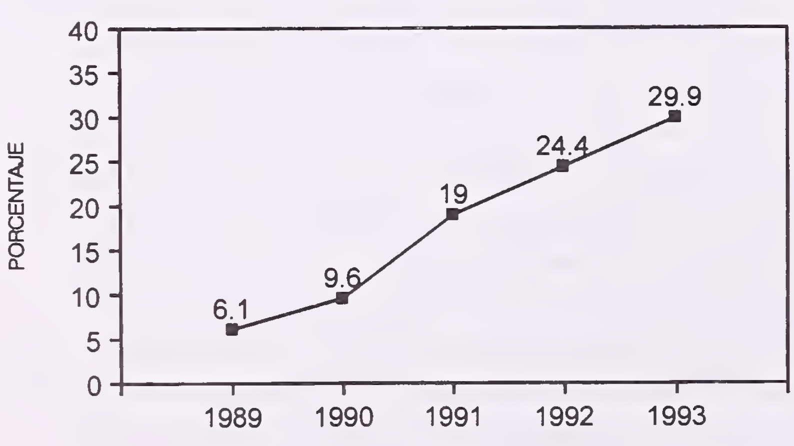

Figura 1. Incremento en el porcentaje de productos de madera importados entre 1989 y 1993 con respecto a la producción nacional.

Reconociendo que hasta que no logremos que los recursos forestales representen una alternativa económica viable para sus pobladores, no podremos empezar a hablar de manejo sostenible, es necesario que antes de proponer criterios y desarrollar métodos para evaluar la sostenibilidad hagamos un análisis de los factores que han obstaculizado el manejo sostenible de bosques en México y de cuales son las condiciones mínimas necesarias para asegurar que este manejo se pueda dar. Con estos antecedentes, mi objetivo en esta memoria es analizar cuales son esas condiciones mínimas necesarias para un manejo forestal sostenible discutiendo porqué dichas condiciones no se han dado en México. Además planteo un marco de referencia que pueda servir para generar criterios de diagnóstico del potencial que tiene una región o predio forestal de lograr un manejo forestal sostenible a largo plazo.

EL CONCEPTO DE SOSTENIBILIDAD EN EL MANEJO FORESTAL

La sostenibilidad no es un concepto nuevo en el manejo de bosques. Desde sus inicios la práctica de silvicultura tanto en México como en el resto del mundo ha tenido como uno de sus objetivos principales asegurar el rendimiento sostenido de los productos maderables que se obtienen de él. Sin embargo, en los últimos 10 años, tanto científicos como manejadores de recursos forestales, han empezado a reconocer la importancia de considerar, no solamente la sostenibilidad de unas cuantas especies forestales de valor comercial, sino también la conservación de otros bienes y servicios ambientales que ofrecen los bosques. El agua, el suelo, la biodiversidad, y el reservorio de carbono, son algunos de los beneficios ambientales más importantes asociados a los bosques que es necesario de mantener.

El surgimiento de un paradigma ambiental que reconoce el papel multifuncional de los recursos forestales ha provocado que muchas de las técnicas tradicionales de manejo forestal sean cuestionadas en relación a su capacidad de asegurar la manutención de todos los bienes y servicios que proporcionan los bosques. A raíz de esta discusión surge un nuevo concepto de manejo forestal

conocido como "manejo de ecosistemas" que pretende ampliar los horizontes del manejo tradicional para incorporar más elementos ecosistémicos a las prácticas de manejo que aseguren la sostenibilidad del ecosistema como unidad integral. En la discusión de este tema se reconoce, sin embargo, que en la actualidad no se cuenta con la información necesaria para mejorar las técnicas de manejo tradicionales y se hace hincapié en la necesidad de plantear una estrategia de transición durante la cual deberá asegurarse la generación de los conocimientos básicos necesarios para lograr las metas deseadas.

Es evidente que cuando incrementamos el número de objetivos en nuestros planes de manejo forestal para considerar bienes más allá de los productos forestales, y sobre todo cuando estos objetivos no son del todo compatibles entre si, no podemos dejar de preguntarnos si en este nuevo contexto los bosques podrán seguir satisfaciendo la demanda de productos forestales y al mismo tiempo asegurar la permanencia de los demás bienes y servicios que como sociedad nos interesa conservar. Ha comenzado a haber un amplio reconocimiento de que la conservación de los beneficios ambientales de los bosques tiene costos que pueden ser muy altos. Por otra parte, también se reconoce que para asegurar la sostenibilidad de los bosques en general, los costos de la conservación deben ser distribuidos de una manera más equitativa entre todos sus beneficiarios evitando que recaigan únicamente sobre los dueños o usufructuarios de los recursos. Esto, sin embargo, tiene implicaciones de escalas temporales y espaciales que son difíciles de manejar; ya que, por ejemplo, los costos y beneficios que se generan a una escala local pueden percibirse o afectar a escalas regionales o globales en tiempos diferentes.

A pesar de haber un reconocimiento de la importancia de manejar los recursos forestales con un enfoque más integral que involucre objetivos múltiples, es necesario reconocer que las prioridades de conservación van a variar para cada caso dependiendo de una serie de condiciones que incluyen desde las características biológicas del bosque hasta aspectos socioeconómicos. Dependiendo del tipo de sociedad y su nivel de desarrollo, la demanda de recursos que provienen del bosque puede variar enormemente. Podemos tener desde países desarrollados donde el aprovechamiento forestal es altamente tecnificado, forma parte de una economía de escala, y se concentra en zonas boscosas de alta productividad en las que se practica una silvicultura intensiva; hasta países en desarrollo donde el aprovechamiento responde más a las necesidades de una economía rural y éste se enfoca a usos locales de subsistencia como la corta de leña para energía doméstica o de madera para construcción de vivienda rural. Por otro lado las características biológicas de cada bosque determinan el patrón de uso y el tipo de manejo que se puede practicar en ellos. No es lo mismo el tipo de recursos maderables o beneficios ambientales que puede ofrecer un bosque templado comparado con los que ofrece un bosque tropical; además, las técnicas de manejo silvícola que se practican en un bosque templado tienden a ser mucho más simples y eficientes que las que se necesitan desarrollar en bosques tropicales para asegurar la sostenibilidad. Los bienes y servicios que ofrecen cada uno de estos tipos de bosques también varía en cuanto a su importancia. Por ejemplo, la conservación de un bosque templado de una zona montañosa podría ser muy importante para mantener los procesos hidrológicos de una cuenca, mientras que en un bosque tropical ubicado en una planicie costera, probablemente sea mucho más importante la biodiversidad.

Dada esta complejidad en la implementación del manejo forestal, a pesar de que los objetivos y las metas de la sostenibilidad pueden ser comunes a cualquier situación, las necesidades de uso del recurso y los métodos para hacer operativo el manejo sostenible van a variar dependiendo de la sociedad y el tipo de recursos de que se trate. En este contexto, es sumamente necesario definir, con criterios claros y objetivos, lo que la sociedad en general espera del papel actual y futuro de los bosques, de las comunidades que los habitan, de las economías que los rigen y de los beneficios ambientales asociados a ellos. Solo si logramos establecer estos criterios con éxito es que podremos desarrollar estrategias adecuadas para llegar a las metas propuestas y diseñar criterios de diagnóstico que nos permitan saber si nos estamos aproximando a dichas metas.

CONDICIONES PARA UN USO SOSTENIBLE DE RECURSOS FORESTALES

Las zonas boscosas de México están habitadas por mas de 10 millones de campesinos, muchos de ellos pertenecientes a grupos indígenas importantes y que en muchos casos han sido marginados. El régimen de propiedad de estas zonas se distribuye de la siguiente manera:

Tipo de propiedad	Superficie %
Social (ejidos y comunidades)	80%
Privada	15%
Federal (incluye áreas protegidas)	5%

La mayoría de las comunidades que habitan estas zonas forestales no han logrado aprovechar sus recursos forestales para cubrir sus necesidades de subsistencia y mejorar su nivel de vida. En muchos casos, son estos los pobladores rurales más pobres del país.

El análisis de la situación de estas comunidades nos lleva a plantear que para lograr la sostenibilidad en el manejo de los recursos forestales del país es necesario asegurar que los poseedores o usufructuarios de estos recursos puedan vivir de su aprovechamiento obteniendo beneficios suficientes para mantener y elevar su nivel de vida. Si estas necesidades no son satisfechas primero, no podrá lograrse un manejo sostenible de bosques que contemple todos los bienes y servicios ambientales asociados e ellos.

Satisfacer estas necesidades, sin embargo, no es una tarea fácil y para lograrla es necesario que se cumplan una serie de condiciones mínimas que pueden analizarse en relación a tres rubros generales: (1) Equidad, es decir que existan las condiciones que aseguren que los dueños de bosques tengan acceso tanto a los recursos naturales y financieros para llevar a cabo el manejo, como a los beneficios que se deriven de ellos; (2) Capital natural, es decir que los bosques contengan un capital inicial mínimo de recursos aprovechables, cualquiera que estos sean; y (3) Eficiencia, es decir que los productores tengan los elementos para optimizar desde las labores de aprovechamiento, hasta la industrialización y comercialización de los productos que se obtengan del bosque, para poder mantenerse competitivos en el contexto de una economía abierta.

A continuación analizo, para cada uno de estos rubros, cuales son las barreras que han existido, y aún existen, en México para lograr que se den las condiciones mínimas previas para asegurar el éxito de un uso sostenible de recursos forestales.

Equidad

Muchos de los problemas de equidad en el uso de los recursos forestales de México están asociados a la carencia de una política clara y consistente de desarrollo del sector forestal. Tradicionalmente, la política de desarrollo del país ha estado orientada a fomentar a la agricultura y la ganadería y a subestimar el potencial de los bosques como recuso económico importante. Esto ha provocado que el apoyo institucional y financiero sea incipiente o nulo hacia actividades forestales en contraste con actividades agropecuarias. Por otro lado, la incipiente política forestal que ha existido en México ha favorecido a la industria, descuidando el apoyo al desarrollo rural de los pobladores del bosque (Warman 1972, Jardel 1990). Desde mediados del siglo pasado, el gobierno concesionó grandes extensiones de bosques a empresas forestales que pagaban a sus dueños una renta mínima conocida como "derecho de monte" por el usufructo de los recursos maderables. Las concesiones se otorgaban por períodos que variaban de 10 a 40 años y podían ser renovadas. Prácticamente hasta los años 70´s, y salvo muy contadas excepciones, las empresas concesionarias, regidas por una política de maximización de ganancias, explotaron grandes extensiones de bosques tropicales y templados del país sin usar un sistema silvícola ni rigiéndose por regulación alguna. El aprovechamiento de estas empresas consistía básicamente en hacer cortas selectivas extensivas de los árboles de mayores dimensiones, dejando como residuo el arbolado enfermo, de condiciones más precarias y, por consiguiente, de menor valor. Estas prácticas han conducido a una severa descapitalización y deterioro de los recursos forestales de muchas regiones del país. Este tipo de aprovechamiento es aún en la actualidad la forma más común de uso de los recursos forestales. Se ha calculado que a pasar de que el 80% de la producción forestal se

obtiene de terrenos ejidales o comunales, el 60% de estas comunidades venden su madera en pie a través de algún tipo de concesión (Martínez 1985).

Otro problema asociado a la equidad ha sido la falta de definición o la definición ambigua de derechos de propiedad de áreas forestales. Aún bajo el esquema de propiedad comunal o ejidal, los derechos de propiedad de terrenos agrícolas o ganaderos han tendido a estar claramente definidos, es decir, los terrenos se dividen y asignan a grupos o familias. En contraste, las áreas forestales de un ejido o comunidad generalmente no se fraccionan ni asignan a ningún miembro de la comunidad, sino que permanecen como áreas de uso común para todos los habitantes de la comunidad o ejido. Cuando los recursos forestales no son una prioridad en la economía ejidal, este esquema, como puede suponerse, ha generado problemas de acceso abierto que han conducido al saqueo de los recursos y deterioro del bosque en general. Cabe hacer notar que a pasar de que este patrón ha sido el común denominador en muchas partes del país, en regiones donde la actividad forestal es prioritaria en la economía local, como es el caso de muchas zonas de Chihuahua, Durango, Oaxaca y Michoacán, por citar algunas, las comunidades han establecido y hecho operativas reglas de uso para evitar la sobreexplotación del recurso forestal y disminuir o erradicar el problema de acceso abierto.

Capital Natural

El capital natural lo podemos definir como todos aquellos bienes y servicios que la sociedad puede obtener de los bosques; desde bienes tangibles como productos maderables y no maderables, hasta los más intangibles como el control del microclima y la biodiversidad. Estos bienes y servicios están asociados a estructuras y procesos particulares del bosque y por consiguiente varían en su disponibilidad y en la manera en lo que la sociedad se beneficia de ellos dependiendo, por un lado, del tipo de recurso forestal de que se trate, y por otro, de la escala temporal y especial en la que estos operen. De esta manera, el capital natural puede incluir desde, por ejemplo, las existencias de volúmenes de madera o el valor estético de un bosque, que se perciben a una escala local; la producción de agua de una cuenca hidrológica, que se percibe a escalas regionales; y la biodiversidad o la conservación y secuestro de carbono que se perciben a escalas mas bien globales. Mientras mayor es la escala a la que se perciban los beneficios, es común que grupos sociales que se benefician de ellos se encuentren más alejados del recurso y por lo general no se percatan de él.

El capital natural es uno de los factores más importantes para instrumentar la sostenibilidad en el manejo forestal. Es este capital el que va a permitir que los dueños del recurso tengan la oportunidad de vivir de él, creándose de esta manera los incentivos necesarios para su buen manejo y conservación. Si de entrada el capital natural no existe o se encuentra deteriorado, o no hay posibilidad de tener acceso a él, la conservación del recurso puede verse severamente amenazada. En estos casos la intervención del estado para corregir la situación se vuelve necesaria.

Naturalmente no todos los bosques tienen el mismo tipo de capital natural ni este se encuentra disponible de la misma manera y en la misma cantidad. Algunos bosques ofrecen un mayor número de bienes y servicios que están eficientemente integrados a mercados establecidos, mientras que en otros los bienes y servicios que se ofrecen pueden no estar incorporados a mercados eficientes o simplemente no haber mercados para su comercialización. En este último caso, una manejo sostenible se vuelve más complicado.

En relación a como el capital natural varía en su disponibilidad podemos hablar de cuatro condiciones generales: (1) cuando el recurso no contiene un capital natural; (2) cuando el capital ha sido minado, o saqueado por aprovechamientos no sostenibles; (3) cuando no existe ni infraestructura ni tecnología apropiadas para aprovechar el capital; y (4) cuando los mercados para su comercialización no existen o son ineficientes.

El caso de capital inexistente, aunque no es una condición común, ya que casi siempre existe un grupo social que se beneficia de un recurso determinado, puede darse en zonas aisladas en donde el tipo de bosque y las condiciones del medio físico no permiten un aprovechamiento rentable de ninguno de sus bienes o servicios.

Para poder asegurar la sostenibilidad de un recurso es necesario que la tasa de extracción de dicho recurso no exceda la tasa a la que éste puede

ser reemplazado naturalmente. La disminución o eliminación de capital natural de recursos forestales es un problema común en México y representa una de las barreras al manejo sostenible más graves y costosas de corregir. Esta condición puede surgir como resultado de dos tipos de prácticas forestales: (1) la explotación de bosques a través de concesiones en donde, como se mencionó en el apartado anterior, hay un saqueo del arbolado de mayores dimensiones y mejor calidad, y no se invierte en tratamientos silvícolas para asegurar la regeneración y protección del bosque; y (2) aprovechamientos forestales en donde se usan sistemas silvícolas inapropiados. En este último caso están muchos bosques del país que han sido sometidos al sistema silvícola conocido como Método Mexicano de Ordenación de Bosques (MMOB) (Rodríguez *et al*. 1959) que es un sistema de extracción selectiva de baja intensidad que se ha aplicado indiscriminadamente a grandes extensiones de bosques tanto templados como tropicales desde fines de los 50´s.

Este método resulta inapropiado para el manejo de la mayoría de los bosques templados de pinos y tropicales de caoba y cedro por dos razones principales: (1) tiene la gran limitación de impedir la regeneración de especies no tolerantes a la sombra (e.g. pinos y caobas); y (2) promueve la extracción selectiva del arbolado de mayores dimensiones y mejores formas dejando un arbolado residual que no tiene la capacidad de crecer a las tasas esperadas. Esta situación conduce a formar masas forestales deterioradas con el potencial de crecimiento reducido; es decir masas forestales descapitalizadas. A pesar de haber sido ampliamente criticado (Musálem 1979, Jardel 1985) en la actualidad el MMOB, o versiones modificadas de éste, aún se siguen usando en 57% de los bosques comerciales del país (SARH, 1992).

El caso en el que el acceso al capital se ve limitado por falta de tecnologías o mercados es el de muchos bosques tropicales no sólo de México sino del mundo. En relación al capital de productos maderables, este tipo de bosques tienen una diversidad de especies arbóreas muy elevada, de la que sólo unas cuantas especies tienen valor comercial y representan un porcentaje relativamente bajo del volumen total existente. El resto de las especies de estos bosques tienen densidades y volúmenes muy bajos que no justifican su aprovechamiento. Otra limitación es que muchas especies con valor comercial potencial tienen maderas con características que las hacen ser difíciles de procesar y para las que no existe una tecnología desarrollada. Ejemplos de estas son maderas preciosas que tienen una densidad elevada y requieren de un equipo especial para ser aserradas o de maderas que son difíciles de secar y muy susceptibles a rajarse o a ser infestadas por hongos y otras plagas que afectan su calidad. Por otro lado existen muchas especies de maderas denominadas corrientes, que tienen un valor muy bajo y para las que no existen un mercado establecido.

Además de los recursos maderables, los bosques tropicales ofrecen otros tipos de capital natural como la biodiversidad, el valor estético y la fijación y conservación de carbono. Desgraciadamente, para este tipo de capital natural no se han establecido aún mercados eficientes y por esto los beneficios que generan no representan una alternativa económica viable para sus dueños.

Eficiencia

Debido a que el tipo de capital natural más importante como alternativa económica para los dueños de los bosques mexicanos son los productos maderables, y ya que los principales productores forestales del país son organizaciones de ejidos y comunidades rurales de las zonas boscosas del país, esta sección estará dedicada ha hacer una análisis de los factores que afectan la eficiencia de dichos productores con respecto a la producción de productos maderables.

A pesar de que en la actualidad el rentismo en los terrenos forestales de México sigue siendo el patrón de uso común de los bosques, conforme el esquema de concesiones forestales ha ido desapareciendo desde principios de los 70´s muchos pobladores de estas áreas, han constituido organizaciones de productores forestales con el fin de lograr un manejo más eficiente y equitativo de sus bosques. Este nuevo tipo de organización ejidal se caracteriza porque los dueños del bosque ya no venden su madera en pie o a pie de brecha sino se han convertido en pequeños productores absorbiendo los costos de caminos, extracción,

servicios técnicos transporte de la madera al aserradero y, en muchos casos, han invertido también en establecer aserraderos pequeños. Este patrón más "vertical" de organización de los ejidos se ha desarrollado como medida para eliminar intermediarios y dar un mayor valor agregado a los productos forestales, incrementando así los beneficios que se obtienen del bosque.

Desgraciadamente, en muchos casos esta tendencia natural de muchas de las organizaciones hacia una mayor independencia y equidad en la distribución local de beneficios ha provocado que no se logre un nivel mínimo de eficiencia en las actividades productivas. Esta situación, aunada a otros factores, ha provocado que los productos forestales mexicanos sean cada vez menos competitivos ante productos provenientes de mercados internacionales, sobre todo a partir de la apertura comercial de México a otros mercados.

Entre los factores que determinan la competitividad de los productos forestales mexicanos en los mercados internacionales encontramos aquellos que no son modificables por el productor y en los que el productor puede tener una influencia importante. Los factores no modificables, incluyen, por ejemplo, la distancia de las áreas de producción a los mercados, y el hecho de que, dado que México es un productor marginal de productos forestales y no tiene influencia sobre los precios internacionales, el nivel de precios internacionales está determinado por otros países. Los factores que si pueden ser modificados por el productor tienen que ver con la eficiencia de manejo, extracción, industrialización y comercialización de los productos forestales.

A continuación discutiré algunos de los obstáculos más importantes que afectan la eficiencia de los productores en las actividades que se llevan a cabo en el bosque, el transporte, la industria, y la comercialización de los productos forestales.

Actividades en el bosque

Los principales problemas de eficiencia asociados a las actividades de manejo y extracción de productos forestales en el bosque están relacionados a tres condiciones principales:

1. Baja productividad de los bosques y calidad inferior de los productos forestales: esta situación es en gran medida resultado de la historia de manejo y del tipo de sistema silvícola que se emplea. La explotación de bosques a través de concesiones y el uso inapropiado de sistemas silvícolas que se discutió en las secciones anteriores son responsables de una disminución en la productividad y en el deterioro de el recurso en general.

2. Costos de extracción: que en muchos casos son elevados artificialmente como resultado de políticas salariales para beneficiar a las comunidades y que se traducen en sueldos muy por arriba de los salarios mínimos vigentes en las zonas productoras. Otro problema que incrementa los costos de extracción está asociado a la organización para la extracción. En numerosas organizaciones predomina el afán de ocupar a los miembros de la comunidad en las labores de extracción independientemente de sus destrezas o grado de capacitación. La vigencia de muchos puestos claves que requieren de experiencia es por tiempo limitado, lo que evita que la gente adquiera experiencia y permanezca en los puestos claves indefinidamente.

3. Costos de transporte: principalmente de la materia prima a los centros de acopio o transformación, que por una ubicación inadecuada de los aserraderos respecto a las zonas de extracción, la madera en rollo tiene que viajar distancias muy largas (hasta de 500 Km). Los costos de transporte también se incrementan debido a que el parque vehicular utilizado por las organizaciones es insuficiente, anticuado o de baja capacidad.

El transporte

En general la infraestructura de comunicaciones para los productos forestales en México es poco competitiva comparada con la de otros países productores de madera como Estados Unidos y Canadá. Por un lado, esto se debe a que las condiciones naturales como la topografía accidentada dificultan y encarecen la construcción y mantenimiento de caminos. Pero por otro lado, a diferencia de otros países, no existe en México un

sistema de ferrocarriles apropiado y, sobre todo, hay una gran carencia de apoyo oficial para la construcción y mantenimiento de caminos de acceso a las zonas forestales.

En muchas áreas forestales del país, las organizaciones de productores son las que han asumido los costos de construir y mantener una red de caminos que beneficia no solamente a las actividades forestales sino también a actividades agropecuarias y comerciales. Por lo general los productores forestales imputan los costos de los caminos a los costos del aprovechamiento y esto hace que los costos de los productos se eleven considerablemente y por consiguiente se vuelvan menos competitivos en los mercados locales o internacionales. Esta situación contrasta con la de países como Estados Unidos y Canadá en los que los costos de caminos y otro tipo de infraestructura son parcial o totalmente absorbidos por el estado.

La industria

Uno de los factores más determinantes de la eficiencia del sector forestal rural es el que tiene que ver con la escala de producción, la eficiencia y la ubicación de las industrias forestales de aserrío. Estas industrias han sido establecidas por las comunidades rurales forestales con el objetivo de dar mayor valor agregado a los productos que obtienen del bosque. Desgraciadamente, la mayoría de estos aserraderos son de escala muy pequeña, tienen tecnologías pobres o anticuadas y su organización para la producción es inadecuada. En 1993, había inscritas en el padrón de empresas registradas de la SARH un total de 1,322 plantas de aserrío con una capacidad conjunta de procesamiento anual de 10 millones de metros cúbicos de madera en rollo (SARH, 1993). La capacidad de estos aserraderos en promedio es muy baja 7,600 m^3/año (3.2 millones de pies tabla), mientras que aserraderos de tamaño mediano en países como Estados Unidos, llegan a producir hasta 47,000 m^3/año (20 millones de pies tabla) de madera aserrada por año. En general se puede decir que este tipo de aserraderos pequeños tienden a tener coeficientes de aserrío (eficiencia de transformación de madera en rollo a madera aserrada) muy bajos, lo que hace que sus costos por unidad de producto sean mayores que los que tendría un aserradero con una capacidad igual a la suma de las capacidades individuales.

En cuanto a la organización para la producción y la productividad, en los aserraderos, al igual que en las actividades de extracción, la organización para la producción tiene problemas asociados a la falta de personal adiestrado y con experiencia y la inflación artificial de los salarios de los trabajadores como política de apoyo a los miembros de la comunidad. También, paralelo al modelo de integración vertical, se ha desarrollado un patrón de diversificación de productos en los que todas las organizaciones aspiran a producir todo tipo de productos, aunque no cuenten con el capital, la tecnología o las materias primas adecuadas. Esto ocasiona que no pueda haber una especialización en la producción en la que se asegure la calidad de los productos.

Otro problema importante de la industria de aserrío es que la capacidad instalada no se encuentra distribuida de manera proporcional con respecto al potencial de incremento anual de los bosques. El estado de Chihuahua, por ejemplo, tiene la mayor capacidad instalada del país (30.2%), y esta es 75% superior al incremento anual de sus bosques: Esta situación provoca que Chihuahua solo pueda ocupar un 43% de su capacidad instalada para procesar madera local y que para incrementar su nivel de uso tenga que importar madera en rollo de otras regiones. En contraste, Durango y Oaxaca tienen una capacidad instalada inferior al incremento anual de sus bosques, pudiendo procesar únicamente el 64% y 47% respectivamente de la madera que producen, y que por lo tanto se vean en la necesidad de exportar madera en rollo para procesar en otros estados. Esta situación provoca, por un lado, que la capacidad industrial tienda a estar subaprovechada y por otro, que la madera tenga que viajar grandes distancias para ser procesada, incrementando así sus costos de producción.

La eficiencia en la industria de aserrío también se ve afectada por la relación que hay entre el coeficiente de aserrío y la ubicación del aserradero con respecto al bosque y al mercado. Un bajo coeficiente de aserrío se traduce en un mayor consumo de madera en rollo por metro cúbico de madera aserrada. Por otro lado, mientras más

alejado esté el aserradero del bosque, mayor será el costo de transporte. Por ejemplo, si consideramos dos aserraderos con coeficientes de aserrío diferentes (del 40% y el 50% respectivamente), los costos de transporte del aserradero al mercado serán los mismos cuando ambos aserraderos estén ubicados cerca del bosque. Este costo comienza a aumentar a medida que el aserradero se aleja del bosque para acercarse al mercado y el costo será mucho mayor para el caso del aserradero con el menor coeficiente de aserrío (Figura 2). Esta diferencia se debe a que con estos coeficientes de aserrío se requiere trasladar por lo menos dos metros cúbicos de madera en rollo por cada metro cúbico de madera aserrada que se enviará al mercado. La conclusión de esté análisis es que entre más alejado este el aserradero del bosque los costos asociados al transporte serán mayores. Desgraciadamente, como se mencionó anteriormente, la mayoría de los aserraderos de México no están ubicados considerando este criterio.

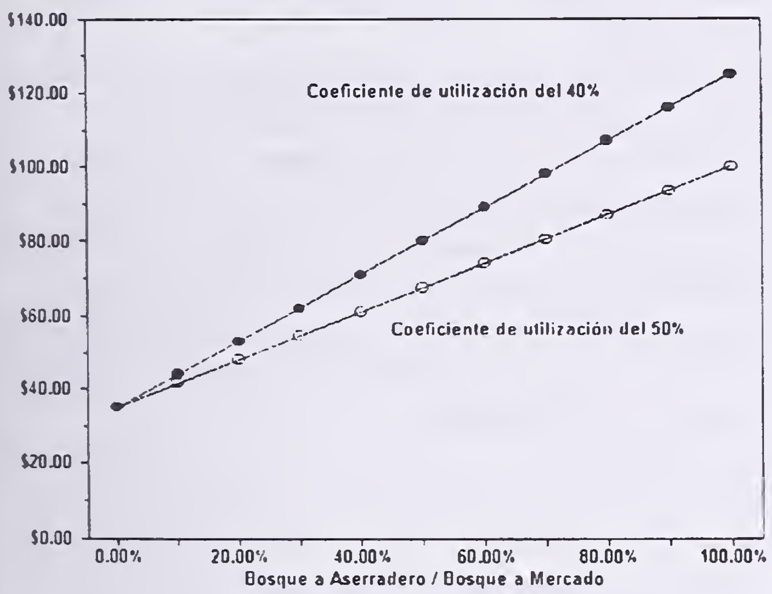

Figura 2. Evolución de los costos de transporte en función de la distancia del aserradero al mercado y de su coeficiente de utilización.

Comercialización

La función de comercialización es otro de los principales elementos que determinan la eficiencia de los productores forestales. Los principales problemas asociados a la comercialización pueden resumirse en los siguientes puntos:

- *Sistemas de información básica al consumidor:* En general no existe información sobre los volúmenes de producción y precios en las distintas zonas de producción que estén al alcance de compradores potenciales. Esta carencia ha impedido el desarrollo de canales de comercialización más eficientes y ha dificultado el desarrollo de un sistema comercial en el país que garantice la seguridad de suministro buscada por los consumidores.

- *Mercados regionales:* No existe una estructura de mercados regionales. El mercado funciona en base a listas de clientes de cada organización de productores sin que exista un mecanismo regulador de la oferta que racionalice el suministro a través del centro productor más próximo al consumidor. El predominio de esquemas individuales de comercialización ha impedido también el desarrollo de patios de madera en rollo y aserrada que podrían propiciar la concentración y segregación de los diferentes tipos y calidades de productos, haciendo la comercialización más eficiente.

- ***Certificación y normalización de productos.*** En México no hay sistemas de certificación formal de la madera que aseguren estándares de calidad homogéneos congruentes con los de otros países, que por lo general tienen estándares internacionales únicos adoptados por los mismos productores. También, a diferencia de otros países, en México no existen sistemas de normalización de medidas comerciales que permitan organizar mejor los mercados de la madera. Estas carencias afectan directamente la competitividad de los productos mexicanos en los mercados internacionales.

CONCLUSIONES

Para poder establecer criterios y desarrollar métodos adecuados para evaluar la sostenibilidad es necesario contar con una serie de condiciones mínimas que desgraciadamente no se cumplen en la mayoría de las regiones forestales de México. Estas condiciones están relacionadas con la equidad de los dueños del bosques en el acceso a los recursos, la disponibilidad de capital natural que ofrecen los bosques, y la eficiencia en el uso de los recursos. Mientras no se logre llegar a un nivel mínimo en el que estas condiciones permitan a los habitantes de los bosques subsistir y mejorar sus condiciones de vida, será muy difícil lograr un manejo sostenible de todos los bienes y servicios que ofrecen los bosques a largo plazo. Dadas estas circunstancias, es importante diseñar estrategias que permitan entrar en una etapa de transición en la que se vaya asegurando que los propietarios tengan cada vez mayor acceso a los recursos en un contexto más equitativo, que los recursos forestales descapitalizados vuelvan a enriquecerse, y que los productores cuenten con los medios y la asistencia técnica necesaria para alcanzar niveles de eficiencia que les permitan ser competitivos en los mercados internacionales.

En esta etapa de transición es muy importante que los esfuerzos que se lleven a cabo para corregir los problemas se hagan con un enfoque integral, es decir atendiendo los problemas asociados a la equidad, capital natural y eficiencia de una manera conjunta. Si únicamente se atienden ciertos problemas y se descuidan otros no se estarán creando las condiciones necesarias para un manejo sostenible. Por ejemplo, si una comunidad se vuelve más eficiente en el manejo forestal y esto le permite producir un mayor volumen de madera de mejor calidad pero descuida la industrialización o comercialización de los productos, seguirá teniendo problemas de rezago competitivo.

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Manejo aplicado a la sostenibilidad

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Resumen.— No es posible lograr la sostenibilidad de los recursos naturales si no se entiende su estrecha correlación con la raza humana y el papel tan importante que juegan para la subsistencia de la misma. A través de los años, el hombre ha sobrevivido en base a la satisfacción de sus necesidades a partir de los recursos naturales. Los bosques pueden mantenerse en forma sostenible, sin la intervención humana, sin embargo al ser utilizados por el hombre requieren de su intervención para asegurar su sostenibilidad en el tiempo y en el espacio, surgiendo de este modo la ingeniería forestal. Esto es especialmente válido si se considera que en toda sociedad existen grandes contradicciones que ponen en peligro la persistencia de los recursos naturales. El sistema de producción de los recursos naturales es muy amplio y complejo, comprende: los bienes primarios, los de valor agregado, los energéticos, los alimentarios y medicinales, los recreativos y culturales, así como los ecológicos.

Para lograr la sostenibilidad de los anteriores, debe considerarse al hombre como propietario y usuario de todos ellos, así como los límites del conocimiento y los cortos períodos de tiempo de la vida humana, la estructura científica, técnicas organizativas y administrativas, en comparación con los ciclos de vida de los bosques y los tiempos requeridos por los recursos naturales. Resulta especialmente importante reconocer que el buen manejo de los recursos naturales puede apoyar muy vigorosamente el desarrollo de los núcleos de población más pobre. generando fuentes de empleo y satisfaciendo sus necesidades, sin comprometer la existencia de las generaciones futuras. El compromiso debe ser, enseñar a los niños el amor y el respeto por los recursos naturales, así como el buen uso que debe hacer la humanidad de ellos

INTRODUCCION

"Entonces dijo Dios: Hagamos al hombre a nuestra semejanza; y señoree en los peces del mar, en las aves de los cielos, en las bestias, en toda la tierra, y en todo animal que se arrastra sobre la tierra. Y creó Dios al hombre a su imagen, a imagen de Dios lo creó; Y los bendijo Dios, y les dijo: Fructificad y multiplicaos; llenad la tierra y sojuzgadla, y señoread en los peces del mar, en las aves de los cielos, y en todas las bestias que se mueven sobre la tierra. Y dijo Dios: He aquí que os he dado toda planta que de semilla, que está sobre la tierra, y todo árbol en que hay fruto y da semilla; os serán para comer. Y a toda bestia de la tierra, y a todas las aves de los cielos, y a todo lo que se arrastra sobre la tierra, en que hay vida, toda planta verde les será para comer. Y fue así" (Génesis 1:26-30).

No. No se trata del sermón dominical, ni de una clase sobre la Biblia, es simplemente una reflexión acerca de una gran verdad, ya que aún aquellos que no crean en Dios o en lo que se dice en la Biblia, tienen que reconocer que los recursos

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naturales existen para beneficio de la humanidad y que el hombre, sí se ha multiplicado a niveles en muchos casos, que no son suficientes los frutos y las semillas de las plantas ni los animales de la tierra, ni las aves de los cielos. Sin duda alguna algo ha fallado.

¿Qué es lo que ha ocurrido? A primera vista, tal parece que lo que mejor hemos sabido hacer es crecer y multiplicarnos así como enseñorearnos sobre los propios hombres y destruirnos los unos a los otros, pues si bien nos hemos enseñoreado sobre la tierra es evidente que nuestro señorío, el de la humanidad sin fronteras, no ha sido del todo exitoso como quisiéramos ya que en muchos casos hemos puesto en peligro nuestra propia existencia, pues hemos empujado a nuestros recursos a niveles insostenibles. Tenemos una gran tarea y una gran responsabilidad desde que hemos llegado a este mundo; y es la de enseñorearnos en la tierra, no en el hombre, sin poner en peligro la subsistencia de los recursos naturales y garantizar la sostenibilidad de la raza humana. Es necesario encontrar formas simples y racionales y garantizar la sostenibilidad de la raza humana. Es necesario encontrar formas simples y racionales de aprovechar lo que ofrece la madre tierra de tal manera que la humanidad satisfaga sus necesidades presentes, al mismo tiempo que garantice la satisfacción de las necesidades de las generaciones futuras.

No es posible lograr la sostenibilidad de los recursos naturales si no se entiende su estrecha correlación con la raza humana y el papel tan importante que juegan para la subsistencia de la misma. Hablar de la sostenibilidad de la raza humana, sin considerar la sostenibilidad de los recursos naturales, es imposible ya que nosotros somos parte intrínseca de los mismos, somos indivisibles. Aunque paradójicamente hay quienes creen que los recursos naturales estarían mejor sin los hombres negando que nosotros mismos somos de hecho un recurso natural renovable.

ANTECEDENTES

Es bien sabido que en un principio el hombre vivía de la recolección de productos vegetales y de animales que eran muertos por otros o que morían en forma natural. Con el tiempo fue desarrollando su ingenio y su capacidad para cazar, así como la habilidad de domesticar algunas plantas y animales, volviéndose sedentario y un predador muy poderoso, ya que dejó de depender, por lo menos así lo creyó y en cierto modo hay muchos que todavía lo siguen creyendo, de lo que la madre tierra o la madre naturaleza buenamente le quería dar y comenzó a jugar el papel de «arquitecto de su propio destino».

Con la práctica del sedentarismo empezó también a modificar y a crear sus propias formas de organización social. Lo más significativo es que el hombre reaccionaba básicamente en función de la búsqueda de satisfacción de sus necesidades prácticamente de una manera similar a la de la mayoría de los seres vivientes, y se valía de los recursos naturales para satisfacer sus necesidades fisiológicas tales como respirar, alimentarse, tomar agua, eliminar desechos corporales, conservar la temperatura del cuerpo, descansar, dormir, reproducirse sexualmente, evitar el dolor y conservar la vida, aún a costa de matar a sus semejantes, como continúa ocurriendo hasta nuestros días.

Con el desarrollo de las formas de organización social el hombre fue creando una serie de necesidades diferentes a las fisiológicas o físicas, surgiendo las necesidades adquiridas que pueden ser clasificadas como sociales y como egoístas (Manzanilla *et al.*, 1991).

Dentro de las necesidades sociales, se tienen al amor, el compañerismo, la amistad, el afecto, la necesidad de sentir que se pertenece a algo y que se tiene el respeto de los demás, el prestigio, la seguridad, la protección y el poderse identificar con el papel que le toca a uno jugar dentro de la sociedad.

Dentro de las necesidades adquiridas clasificadas como egoístas, se encuentran entre otras el respeto propio, la autoestima, la libertad de expresión y de creer en lo que uno quiera, la adquisición de bienes, la independencia y el poder. Esta última, causa de muchos sinsabores para el hombre. Aunque por satisfacer cualquiera de las necesidades adquiridas, el hombre ha demostrado a través del tiempo, ser capaz de llegar a los extremos de matar o morir, del mismo modo que lo haría por conseguir la satisfacción de sus necesidades físicas.

Lo importante hasta este punto de la plática, es que la evolución de la raza humana nos enseña que:

- Los recursos naturales y el hombre son uno sólo.

- El hombre se ha servido, se sirve y tendrá que seguirse sirviendo de los recursos naturales para asegurar su existencia.

- El hombre está dispuesto a llegar hasta los extremos con tal de conseguir la satisfacción de sus necesidades, especialmente si está de por medio su supervivencia o la de sus seres queridos.

- Cualquier acción que emprende el hombre ligada con los recursos naturales tendrá que considerar que estos sirven para satisfacer una amplia gama de necesidades físicas y adquiridas de toda la sociedad que de no tomarse en cuenta pueden representar el fracaso de lo que se quiera hacer. El hombre es el actor central.

Para facilitar la comprensión de lo anterior, bastaría citar un ejemplo de medidas extremas que no toman en cuenta a grandes grupos de la población y que por lo tanto están destinadas a fracasar, tarde o temprano.

Veda total de aprovechamientos forestales en una región cualquiera, ocupada por una población que para poder vivir depende de las actividades forestales.

Esta acción es atentatoria contra la satisfacción de una gran variedad de necesidades físicas, sociales y egoístas de un gran sector de la sociedad y a menos que se emprendan desde antes de su aplicación una serie de acciones tendientes a la satisfacción de esas necesidades, pueden surgir reacciones insospechadas como las ocurridas en Chiapas, México.

CONTRADICCIONES DE LAS SOCIEDADES EN DESARROLLO

Las sociedades del mundo especialmente las más desarrolladas, se han preocupado más y más por los contaminantes que respiran, comen y hasta beben, se han asustado de las alteraciones del medio ambiente que ellos mismos han provocado al destruir sus recursos naturales para impulsar su propio desarrollo y crear esos grandes centros urbanos sobrepoblados, llenos de consumidores de recursos naturales que provocan la pérdida de la biodiversidad y alteraciones del medio físico transformando las áreas verdes en grandes bloques llenos de concreto, industrias, vehículos y productos emisores de contaminantes.

De este modo y como consecuencia de todo esto, se ha creado una nueva necesidad que bien podría ser catalogada como una necesidad adquirida egoísta a la que se la ha dado por llamar "calidad de vida". ¿Quién no quiere elevar el nivel de su calidad de vida? Por ello, es cada vez mayor el número de los individuos de nuestras sociedades que reclamamos, con justa razón, que se detenga la destrucción de los recursos naturales pero injustamente queremos que el precio que hay que pagar vaya sobre la población que más depende de ellos para satisfacer sus necesidades físicas, la población más pobre, la de los países en vías de desarrollo y en particular la más pobre de la más pobre, la población rural.

Y así, surgen las cuatro más grandes contradicciones de las sociedades en desarrollo y que trataremos de sintetizar a continuación:

- La primera, se da entre el productor y el consumidor representante de la sociedad en general. El productor casi siempre de extracto rural, demanda de más dinero por su producto buscando la mayor utilidad en el menor tiempo posible, en tanto que el consumidor en su mayoría de extracto citadino, reclama más producto por su dinero buscando satisfacer sus necesidades al menor costo y con el menor esfuerzo posible.

- La segunda, se da entre el productor y los recursos naturales, pues el productor mediante su trabajo, altera el medio ambiente natural, procurando maximizar su producción con la menor inversión posible y buscar ganar más en el menor tiempo posible, a partir de los recursos agua, suelo y biota, en tanto que el medio ambiente de los recursos naturales

demandan, especialmente los forestales, una mayor inversión de capital y tiempo de lo productores, por lo tanto, una disminución de sus utilidades o bien un aumento de su precio de venta y un conflicto con la demanda de los consumidores.

- La tercera contradicción se da entre la sociedad y los recursos naturales porque en su proceso de crecimiento la sociedad, o sea los consumidores, por un lado demandan más productos a partir de los mismos recursos naturales que obviamente son finitos y demandan más alimentos y productos baratos que conllevan a una alteración de los recursos naturales y por otro lado reclaman aire puro, aguas no contaminadas, áreas naturales intocadas, sitios en donde descansar y aliviar la tensión derivada de un entorno estresante y muy contaminado como resultado de la sociedad que nosotros mismos hemos construido.

- La cuarta contradicción se da dentro de la sociedad, especialmente de los países en desarrollo dentro de un fuerte grupo de la población que tiene sistemas de producción de subsistencia. Lo que produce lo autoconsume. Carece de los medios y los conocimientos para producir sosteniblemente y muchas veces hasta de la tierra, por lo que ve a los bosques como un obstáculo para su propia subsistencia. Está más preocupado en sobrevivir que en pensar en las futuras generaciones. La contradicción se da cuando esta parte de la sociedad tiene que destruir para vivir lo que le puede servir para vivir mejor.

Estas cuatro grandes contradicciones, empujan a los recursos naturales a un grado de desorden que irremediablemente conduce a una disminución de los productos que ella misma demanda, cayéndose en un círculo vicioso que nos empuja a la primera contradicción y así sucesivamente con la resultante que se demerita el nivel de ingresos y la calidad de vida de los productores, los consumidores y la sociedad en general. Ejemplos catastróficos derivados de estas contradicciones se ven desafortunadamente casi todos los días en los noticieros de televisión de diferentes partes del mundo.

La humanidad pronto alcanzará seis billones de habitantes en un lugar en donde algunos consideraban que 500 millones era la capacidad natural del planeta. Por consecuencia, se consumirán más recursos de los que se consumen ahora (Manzanilla *et. al.*, 1991). Evidentemente, la superficie de bosques por habitante en el planeta se irá reduciendo cada vez más de una manera dramática.

Es claro que la humanidad debe hacer un repaso de lo que hasta ahora ha venido haciendo. Es necesario una revisión a fondo de nuestras teorías económicas, sociales y jurídicas así como estudiar mucho más los procesos naturales y las tecnologías que nos permitan incrementar la producción de los recursos naturales sin provocar daños irreversibles que pongan en serio peligro la permanencia de la sociedad humana, tal y como la conocemos ahora.

EL SISTEMA DE PRODUCCION SOSTENIBLE DE LOS RECURSOS FORESTALES

Hay evidencias alarmantes de que si seguimos creciendo y destruyendo nuestros recursos naturales agotaremos substancialmente la fuente primaria de donde satisfacemos nuestras propias necesidades y por lo tanto pondremos en peligro nuestra propia existencia. Es necesario entonces, hacer frente a lo que está ocurriendo y encontrar formas viables y factibles de desarrollo sostenible.

¿Qué es lo que en realidad puede esperarse del Manejo Sostenible de los Recursos Naturales Forestales? Tal vez, para entenderlo mejor, convendría que en primer término citemos al célebre silvicultor Heinrich Cotta. En 1816 en su libro "Consejos Silvícolas" (Citado en Baker, 1950) el decía:

"Si todos los habitantes de Alemania abandonaran el país, éste se cubriría de bosques dentro del lapso de un siglo; en vista de que no habría nadie que los utilizara, el suelo se enriquecería y los bosques no sólo incrementarían su tamaño sino también su capacidad de producción. Sin embargo, si la gente retornara otra

vez e hiciera una extracción de madera, forraje, y pastura exactamente igual a la de antes, los bosques, incluso con el mejor manejo forestal, no tan solo se volverían a reducir en tamaño, sino que los suelos se volverían menos fértiles".

"Los bosques surgen y se desarrollan mejor en los lugares donde no hay habitantes (y por lo tanto, tampoco ingeniería forestal), lo que justifica a aquellas personas que dicen que en el pasado no existía la ingeniería forestal y teníamos suficiente madera; empero ahora que contamos con la ciencia, ya no tenemos madera".

"Podría decirse con la misma justicia: las personas que no necesitan de un médico son más saludables que aquellas que si lo necesitan; pero esto no quiere decir que los médicos sean culpables de las enfermedades: no existirían los médicos si no existieran las enfermedades: y no existiría la ciencia forestal si no hubiera una deficiencia en la cantidad de recursos forestales disponibles. Esta ciencia es tan solo hija de la necesidad y la necesidad es, por consiguiente, su causa natural; entonces, la oración debería ser: ahora tenemos la ciencia forestal porque hay escasez y carestía de madera".

"La Ingeniería Forestal sin embargo no ofrece milagros y nada puede hacer contra el curso de la naturaleza. Es decir, así como el médico no puede evitar que los hombres mueran, porque ese es el curso de la naturaleza, tampoco el mejor técnico forestal puede evitar que los bosques, que llegaron a él a modo de una herencia, se deterioren a partir del momento que se les empieza a utilizar".

"En ausencia de utilización el suelo forestal mejora constantemente; si se utilizan los bosques de una manera ordenada, estos permanecen dentro de su equilibrio natural; si se les utiliza irracionalmente se empobrecen. El buen técnico forestal obtiene los mayores rendimientos del bosque sin deteriorar el suelo, pero el malo no puede obtener estos rendimientos ni preservar la fertilidad del suelo".

De lo dicho hasta aquí por Cotta podríamos concluir que el Manejo Sostenible de los bosques es posible en la medida que podamos emular a la naturaleza y mantengamos los bosques dentro de su equilibrio natural. Si rompemos ese equilibrio y deterioramos el suelo, difícilmente lograremos conservarlos.

México no es ajeno a los procesos de crecimiento que está viviendo la humanidad en general y tiene un muy alto número de habitantes que dependen directa o indirectamente de las actividades ligadas con los Recursos Naturales para la satisfacción de sus necesidades. Por regla general se trata de gente que vive en condiciones de extrema pobreza que depende de los recursos forestales para proveerse de leña combustible, aperos de labranza, mangos de herramientas, muebles, casa habitación, forrajes para su ganado, agua para beber, alimentos (hongos, frutos, fauna silvestre, etc.) y medicinas (es bien reconocida la reputación de la herbolaria medicinal mexicana) entre otras cosas.

Esta misma población no es ajena a las cuatro contradicciones de las sociedades en desarrollo a las que hicimos referencia anteriormente en este escrito, pero la situación de parte de ella corresponde al de la cuarta contradicción, la que está más preocupada en su realidad presente; y no en las generaciones futuras. Ve al bosque como su enemigo, como un obstáculo para establecer sus cultivos.

Sin embargo, paradójicamente esos mismos recursos forestales pueden convertirse en sus mejores aliados y ser factor de cambio, contribuyendo a su desarrollo y bienestar social manejados apropiadamente.

En efecto, los recursos naturales forestales bien pueden ser comparados con un sistema de producción que en forma natural sin intervención humana es sostenible en el tiempo y en el espacio, a diferencia de otros sistemas de producción como el agrícola o el ganadero que sólo pueden sostenerse con la intervención del hombre. Por lo cual los recursos naturales forestales bien manejados pueden ser una fuente inagotable de producción de bienes que satisfagan de una manera directa o indirecta las necesidades de una población creciente.

El sistema de producción de los recursos forestales debido a nuestras economías de escala principalmente se le ha identificado con producción de madera; dejando a un lado un sinnúmero de otros bienes que pueden ser y de hecho son más importantes que la misma madera pero que actualmente no existen los mecanismos apropiados para que sean correctamente evaluados y se paguen por ellos los que realmente valen, ya que algunos son bienes intangibles como el

oxígeno, captación de CO_2 de la atmósfera, regulación del régimen hidrológico, calidad del agua, paisajismo, etc.

El sistema de producción de recursos naturales es muy amplio y complejo. Sin embargo puede ser clasificado dentro de seis grandes sistemas de producción de bienes:

1. El sistema de producción de bienes primarios que se subdivide en:

   - Maderables, donde tenemos trozas para: postes de energía, aserrío, triplay, leña, material celulósico, tableros, cercas, construcción, etc.

   - No maderables, donde tenemos productos como las fibras, ceras, látex, resinas, curtientes, etc.

2. El sistema de producción de bienes con valor agregado que son productos que tienen un mayor valor al habérsele aplicado un proceso o varios de transformación generando productos como madera aserrada, chapas, casas, muebles, fijadores de perfumes, anticonceptivos, etc.

3. Sistema de producción de bienes energéticos. Los recursos forestales siendo renovables son una fuente inagotable de producción de energía que tiene posibilidades en un mundo en donde los recursos fósiles de energéticos se están agotando, actualmente influyen en los sistemas de producción de energía eléctrica con la ayuda de la fuerza hídrica y son muy empleados también para obtener leña combustible.

4. Sistema de producción de bienes alimentarios y medicinales. Este sistema no ha sido aprovechado ni valuado adecuadamente ya que sus posibilidades son enormes tanto ligado con otros sistemas de producción como el agrícola, frutícola, ganadero y pesquero, como por sí solo; y así se tienen los cercos vivos, las cortinas rompevientos, las partes vegetativas y reproductivas, hongos comestibles y medicinales, agua para riego, agua para producción piscícola, fauna silvestre, forrajes para fauna doméstica, etc.

5. Sistema de producción de bienes recreativos y culturales. Este es un sistema que está teniendo cada vez mayor importancia entre los miembros de la sociedad, muy especialmente en las sociedades más desarrolladas con mayores recursos y así se tienen algunos productos como: plantas de ornato, fauna silvestre, ecoturismo, parques nacionales, fraccionamientos ecológicos, etc.

6. Sistema de producción de bienes ecológicos. Este sistema es sin duda alguna el más complejo de todos, el más importante, el menos entendido y el más explotado por los demagogos. Está íntimamente correlacionado con la naturaleza y la permanencia misma de los recursos naturales y por ende del hombre. Se le identifica con aire puro y limpio de contaminantes, con agua de alta calidad, con captación de bióxido de carbono con preservación de las especies animales y vegetales así como con producción del suelo y materia orgánica y en general con el equilibrio ecológico. Es fuertemente influenciado por los otros sistemas de producción y es clave para la sostenibilidad de todos ellos. Ignorarlo es sinónimo de fracaso.

COMENTARIOS FINALES Y RECOMENDACIONES

Lo ideal sería que se lograra el óptimo y la producción integrada y sostenida de todos los bienes derivados de los recursos forestales. Nada más alejado de la realidad, ya que para lograr la sostenibilidad de tan complejo sistema de producción se requiere que sea económicamente viable, social y políticamente aceptable así como jurídicamente posible. Sin embargo se debe buscar que impacte sobre el desarrollo de la población rural incrementando el bienestar económico local,

regional y extra regional. Para lograrlo hay algunas premisas que seguramente deben ser válidas y aceptables para la mayoría de los miembros de la sociedad. Tales como:

1. Debido a que lo que sucede con los recursos naturales impacta más allá de los límites físicos de una propiedad y a que las decisiones que se toman rebasan el ámbito de influencia de un propietario, no es moralmente aceptable que el propietario haga lo que quiera con su bosque sin importarle las necesidades de la sociedad, pero del mismo modo resulta igualmente inmoral, que la sociedad trate de tomar decisiones sobre su propiedad sin que considere como contribuir a la satisfacción de las necesidades del propietario.

2. El Manejo Sostenible de los Recursos Forestales no podrá lograrse si no se persigue el desarrollo de la población que se encuentre viviendo o dependiendo de ellos para la satisfacción de sus necesidades físicas. No podrá ser posible mientras exista la pobreza extrema y hambre.

3. El Manejo Sostenible de los Recursos Forestales debe buscar primeramente el bienestar socioeconómico local mediante la generación de ingresos por venta de productos y creación de fuentes de empleo.

4. El Manejo Sostenible de los Recursos Forestales debe buscar un efecto benéfico regional y extraregional mediante la creación de empleos indirectos, ya que por la experiencia de algunos países como Brasil, se puede tener una relación de tres empleos indirectos por cada directo, así como por la generación de divisas, atracción de turismo, aumento de la vida útil de las presas, ingresos al gobierno por impuestos, etc.

5. El Manejo Sostenible de los Recursos Forestales debe ser aceptado por la sociedad y los políticos, porque contribuye a elevar los niveles y la calidad de vida de la sociedad en general.

6. El Manejo Sostenible de los Recursos Forestales es una tarea que rebasa los límites y las posibilidades de un propietario o incluso de una administración ya sea técnica o gubernamental, por lo que requiere de mecanismos muy complejos de planeación estratégica y operacional pero sobre todo de apoyos muy sólidos fundamentados, en normas, reglas y leyes así como en conductas políticas, sociales y económicas que garanticen el alcance de los objetivos y metas que se fije la sociedad y los dueños de los recursos forestales a través del paso de varias generaciones, además de un muy profundo conocimiento de los procesos naturales.

7. En México un esquema muy simplificado a seguir para conseguir el manejo aplicado a la sostenibilidad podría ser:

   - Regionalización Agroecológica del país.

   - Planeación Estratégica del Uso del Suelo.

   - Planeación Estratégica de la producción de bienes por región agroecológica y sistemas de producción de recursos forestales que tome en cuenta a los dueños, la población local, las implicaciones regionales así como a la sociedad en general además de las características intrínsecas de los recursos forestales y el potencial productivo de bienes. Deberá por supuesto, como buen plan estratégico tomar en cuenta las necesidades presentes y futuras de los dueños de los recursos, de los productores potenciales de los consumidores y de la sociedad demandante en general.

   - Implementar programas operativos regionales y locales bajo esquemas técnicos simples, con participación en todos los casos de inversionistas, dueños de los recursos y representantes de la sociedad en general. Los esquemas técnicos deben dejar claro que se quiere evolucionar de lo simple a lo complejo

permitiendo una mejor comprensión por parte de técnicos y de dueños de los recursos de los procesos naturales, así como una clara definición y unificación de criterios acerca de diferentes conceptos de manejo, tales como unidades de manejo por ejemplo. Sin duda alguna sería muy recomendable que estén relacionados con métodos de agrupación ecológicos y con sistemas simples rentables de producción.

- Establecimiento por parte del gobierno de esquemas más modernos de educación, administración y jurídicos así como de promoción y apoyo finaciero, técnico y científicos que permitan la aplicación de planes y programas más allá del límite de vida humana.

Y finalmente el éxito o el fracaso de El Manejo Sostenible de los Recursos Forestales, no debemos olvidarnos, radica en primera instancia en la voluntad del dueño del recurso en lograrlo, sea un propietario o sea la sociedad. Enseguida dependerá del conocimiento que se tenga de la naturaleza, pues lo único que hace un buen manejador es imitar a la naturaleza. Podrá acelerar o retroceder procesos, creando clones híbridos, introduciendo nuevas especies, o provocar ciertos cambios locales en el medio ambiente para crear ciertos ambientes favorables a determinadas etapas de desarrollo de las especies forestales, pero siempre deberá estar vigilante de los efectos de sus acciones sobre su entorno. En la medida en que sus acciones vayan contra Natura, tendrá que invertir más insumos exteriores y por lo tanto elevar sus costos, garantizando de este modo que será mucho más difícil y costoso lograr la sostenibilidad, pues estará más sujeto a los vaivenes impredecibles del mercadeo de las economías de escala y a los procesos caprichosos del desarrollo de la sociedad.

Esta última situación por regla general, está muy fuertemente ligada a esquemas muy intensivos de producción de recursos forestales, que buscan principalmente la producción de bienes primarios a muy corto plazo, buscando la máxima utilidad en el menor tiempo posible. No puede hacerse extensivo sin embargo a la gran mayoría de los bosques del mundo en donde los procesos son más complicados y con mayores lapsos de tiempo; y mucho menos a la mayoría de los países subdesarrollados carentes de capital, de tecnologías, de infraestructura industrial y terrenos adecuados para sistemas intensivos de producción forestal ya que precisamente esos terrenos son más bien destinados para producción agrícola y ganadera para la satisfacción de sus necesidades. Pardójicamente el manejo sostenible de sus bosques naturales parece ser una opción más barata y realista para contribuir a la solución de sus problemas de pobreza extrema y de destrucción de los mismos, al ser vistos como un medio para satisfacer sus necesidades y no como un obstáculo.

La sociedad debe enfrentarse a la realidad y preguntarse a sí misma cual es el precio que quiere pagar por un mundo más justo y más sano, y enseñarse que los recursos naturales, muy específicamente los renovables, deben ser la base para elevar los niveles y la calidad de vida de la población sin comprometer el futuro de las generaciones futuras. Nuestro compromiso es enseñar a los niños el amor y el respeto por los recursos naturales así como el buen uso que puede hacer la humanidad de ellos.

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Aplicaciones de manejo para ecosistemas sostenibles: Un estudio de caso en el Bosque Nacional Klamath

Barbara Holder[1] y Joyce Andersen[2]

Resumen.—Durante casi dos décadas, ha existido una controversia creciente sobre el manejo de bosques de viejo crecimiento en terrenos federales de los Estados Unidos. Cambios en los valores sociales, legislación y litigios, han demandado mayor atención para hacer manejo de ecosistemas sostenibles. En 1992, el Servicio Forestal estableció una política de "manejo de ecosistemas." Manejar ecosistemas sostenibles significa mantener la diversidad biológica en términos de composición, estructura, procesos, y funciones interrelacionadas, mientras se alcanzan las necesidades de la gente. Asociaciones entre comunidades locales, investigadores y administradores están emergiendo a través de aplicaciones del manejo adaptativo. Este artículo describe un proceso y aplicaciones de manejo para hacer sostenibles los sistemas ecológicos.

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ESTUDIOS DE CASO DE MÉXICO Y LOS ESTADOS UNIDOS

El manejo sostenible de los recursos forestales en Quintana Roo

Miguel A. Olayo González[1], Ricardo Ríos Rodríguez[2], L. Alfonso Argüelles Suárez[3] y Daniel González Cortés[3]

Resumen.— Los primeros intentos por lograr un aprovechamiento de los recursos forestales en el Estado de Quintana Roo, datan de principios de siglo, principalmente del palo de tinte, caoba y el chicle. En 1983, los Gobiernos Federal y del Estado de Quintana Roo implementaron una nueva política forestal con el objeto de crear las condiciones para la conservación y el manejo de las selvas. La estrategia de implementación del plan considera las siguientes líneas de acción: Asistencia técnica, manejo forestal, organización y capacitación campesina, industria forestal y comercialización. Este trabajo contempla 4 etapas de implementación que comprenden los años de 1983 a 1994.

INTRODUCCIÓN

México está considerado como un país de vocación forestal, ya que cuenta con una superficie arbolada de 56.8 millones de hectáreas. Sus recursos maderables se han estimado en 2,803 millones de metros cúbicos y sus incrementos anuales en bosques de coníferas en 24.9 millones de metros cúbicos, lo que da idea del alto potencial forestal que tiene.

Es uno de los 17 países que poseen las mayores superficies cubiertas por selvas, 24.6 millones de hectáreas, de las cuales 5.8 corresponden a selvas altas y medianas. Su valor ecológico y social ha generado una gran preocupación por su conservación.

En 1983, en el Estado de Quintana Roo dió inicio una nueva etapa en el aprovechamiento forestal tropical de México. En esta ponencia se destacan los aspectos relevantes en base a un análisis cronológico de la experiencia.

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MARCO DE REFERENCIA

Descripción General Del Area

Localización

El Estado de Quintana Roo se localiza en el extremo oriental de la Republica Mexicana, en la Península de Yucatán. Colinda al norte y noroeste con el Estado de Yucatán, al este con el mar Caribe, al sur con Belice y Guatemala y al oeste con el Estado de Campeche (Figura 1).

Aspectos naturales

Los climas predominantes de la región son los cálidos subhúmedos, con régimen de lluvias en verano y precipitaciones medias anuales que oscilan entre 1,100 y 1,300 mm.

Por el origen geológico de la Península de Yucatán, el área en su totalidad está formada por rocas sedimentarias predominantemente calizas del Cenozoico, lo cual le confiere un relieve ondulado y de superficies planas con pendientes reducidas.

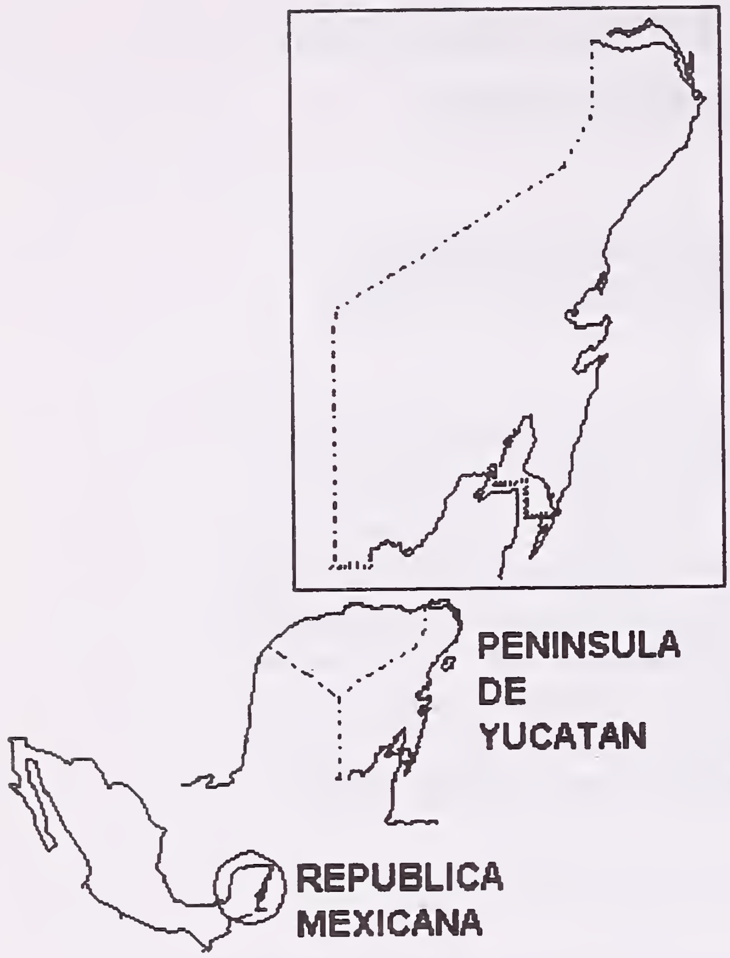

Figure 1.—Ubicación del estado de Quintana Roo

Debido a que el subsuelo está formado por sedimentos calcáreos ya que existe una fuerte disolución por la presencia casi constante de agua, su sistema hidrológico es principalmente subterráneo. Con excepción del Río Hondo, que colinda en la frontera sur con Belice, no existen corrientes superficiales importantes.

TOTAL: 5,035 MIL

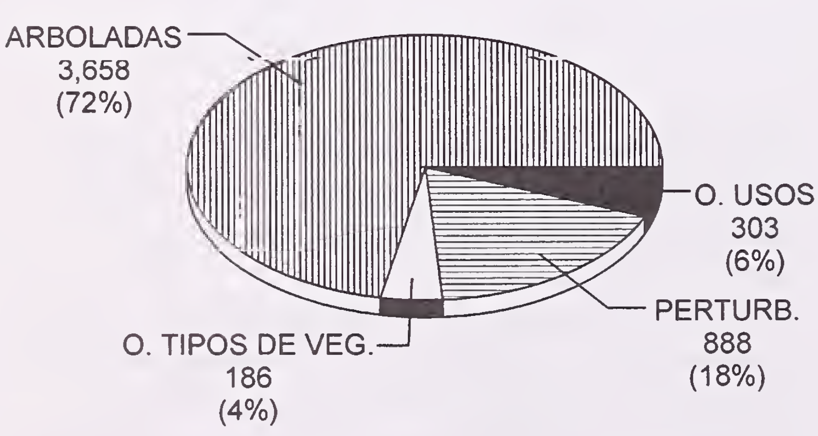

Figure 2.—Superficies del Estado de Quintana Roo

Los suelos en su mayoría son delgados, de textura arcillosa predominantemente a franca, y drenaje de lento a moderado.

Los tipos de vegetación del área son la selvas altas y mediana (que son los que predominan y cuya diversidad de especies es amplia), la selva baja, el manglar y el palmar. Entre las especies de mayor distribución se encuentran el chicozapote (*Manilkara zapota*), pukté (*Bucida buceras*), caoba (*Swietenia macrophylla*), chacá roja (*Bursera simarouba*), tzalam (*Lysiloma bahamensis*), chechen negro (*Metopium brownei*), ramón (*Brosimum alicastrum*), sak-chacá (*Dendropanax arboreum*), chacte kok (*Sickigia salvadorensis*), katalox (*Swartzia cubensis*), pasa'ak (*Simarouba glauca*), cedro rojo (*Cedrela odorata*) y amapola (*Pseudobombax ellipticum*).

Situación Del Recurso Forestal

De acuerdo con el inventario forestal periódico recientemente concluido, la entidad cuenta con una superficie de 5 millones 35 mil hectáreas, de las cuales 3 millones 658 mil tienen cubierta forestal arbolada (72% del total), 186 mil ha corresponden a otros tipos de vegetación, 888 mil ha forestales perturbadas, y 303 mil a otros usos (Figura 2).

En cuanto a superficie forestal arbolada se refiere, 1 millón 614 mil ha están cubiertas por selvas altas y medianas, 835 mil ha por selvas bajas, y 1 millón 209 mil ha por selvas fragmentadas, constituidas estas últimas por selvas parcialmente desmontadas y acahuales (Figura 3).

TOTAL: 3,658 MIL

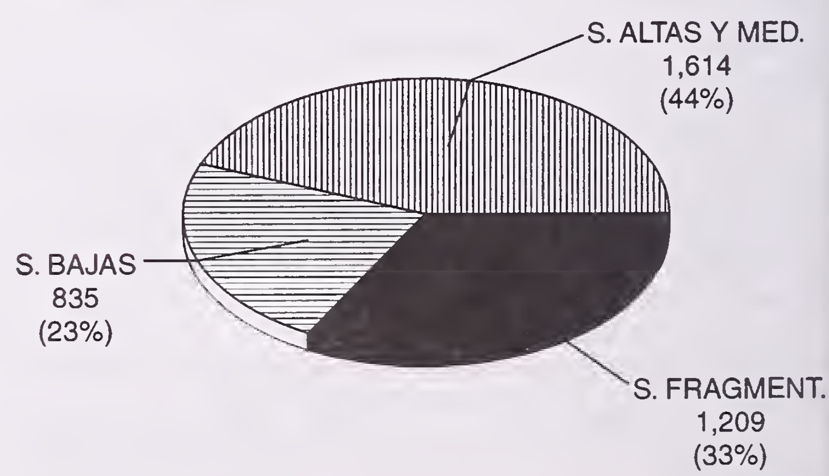

Figure 3.—Superficie Forestal del Estado de Quintana Roo (miles de hectáreas)

Aspectos Socioeconómicos

De acuerdo con el Censo General de Población y Vivienda 1990, la población de la entidad es de 493 mil 277 habitantes, de los cuales 48.3% (238,369) son mujeres y 51.7% (254,908) son hombres, y cuya densidad de población es de 10 hab/km2.

El 73.9% de la población es considerada como urbana y el 26.1% como rural. Una gran parte de los habitantes de las áreas rurales proviene de otros estados de la República, los cuales colonizaron la región en los años 60's.

La población economicamente activa (PEA) es de 277 mil personas, de las cuales 19.6% se dedican a actividades primarias.

Respecto a la distribución de la tierra en la entidad, del orden de 3 millones 20 mil Ha son de propiedad social, y pertenecen a 276 ejidos, 282 mil a propiedad privada (1421 predios), 622 mil a terrenos nacionales, y 1 millón 111 mil a otros (Tabla 1).

Tabla 1.—Superficie del área Forestal Permanente (AFP)

FORMA DE TENECIA	No. PREDIOS	SUPERFICIE (miles de ha)	%
PROPIEDAD SOCIAL	276 EJIDOS	3,020	60.0
PROPIEDAD PRIVADA	1421 PREDIOS	282	5.6
TERRENOS NACIONALES		622	12.4
OTROS		1,111	22.0
	TOTAL	5,035	100.0

PLANTEAMIENTO DEL PROGRAMA FORESTAL

Los primeros aprovechamientos forestales comerciales en el Estado de Quintana Roo datan de principios de siglo. Consistían en la extracción del palo de tinte, la caoba y el chicle, realizada por empresas extranjeras, entre las que puede citarse a la Mahogany Company. Posteriormente, al retirarse las compañias transnacionales, el aprovechamiento forestal paso a manos de permisionarios locales, quienes instalaron los primeros aserraderos en la zona, sin cambiar en nada el modelo de aprovechamiento, el cual era totalmente selectivo.

Los primeros asentamientos campesinos fueron fundados por los mismos trabajadores forestales, tanto de la madera, como del chicle, actividades que coexistían sin conflicto. En los años 30's se otorga la posesión de la tierra en forma de ejidos a los primeros grupos de chicleros. Entre otros, se formaron los ejidos: Nohbec, Caoba, Chacchoben y Petcacab. Las dotaciones de tierra otorgadas, se decidieron con el criterio de formar ejidos forestales, concediéndose 420 Ha **per capita**, que se consideraba como extensión suficiente para la subsistencia de un productor de chicle.

Al obtener derechos sobre la tierra, los ejidatarios pasaron de ser meros trabajadores de los contratistas chicleros, a explotar sus propios bosques. La explotación de la caoba paso a compañías privadas y paraestatales, mediante la concesión de grandes superficies arboladas, condicionadas a la realización de un inventario forestal y a la presentación de un plan de ordenación de montes, ubicándose aquí los primeros pasos serios para el manejo de selvas en el trópico mexicano. De esta manera coexistieron la producción maderera y la extracción de chicle, que representaban la principal fuente de empleo e ingreso para la población rural, dando estabilidad a las áreas forestales, aún cuando no se definían zonas de producción sostenida.

Una de las empresas que recibieron concesiones fue la paraestatal "Maderas Industrializadas de Quintana Roo, S.A." (MIQRO), a la cual le fue otorgada una superficie de 500 mil hectáreas en 1957 por 25 años, período durante el cual, la madera sólo podía ser explotada por ella. Bajo esta concesión, se hizo la explotación selectiva de los bosques cortando sólo cedro y caoba, pagando a los ejidatarios únicamente el derecho de monte (cuota por metro cúbico aprovechado fijada por el Gobierno Mexicano), cantidad que estaba muy por debajo del precio de la madera en la región.

En la década de los 60's, la economía rural del estado sufrió cambios drásticos al iniciarse la colonización del trópico mexicano. Este proceso estuvo apoyado por una fuerte inyección de capital para financiar el desarrollo de una gran cantidad de proyectos agropecuarios, bajo la concepción de que los suelos tropicales constituían reservas de terrenos fértiles.

Ese modelo llevó a que en la mayoría de los ejidos, el bosque comenzara a desaparecer. La falta de participación de los pobladores en las actividades forestales obligó a que estos buscaran alternativas, recibiendo una elevada cantidad de subsidios para desmontes, que causaron una gran merma de la superficie forestal.

Los Gobiernos Federal y del Estado de Quintana Roo preocupados por la conservación de las selvas y por el desarrollo de las áreas rurales, en 1982 iniciaron acciones conjuntas, ordenándose la realización de un diagnóstico del sector en la entidad, el cual permitiera buscar alternativas para frenar la destrucción de las selvas. De estos estudios, surgió el planteamiento de una nueva política forestal, que se implementó a partir de 1983, con el objetivo de crear las condiciones para la conservación y manejo de las selvas.

En este contexto se presentaron ciertas condiciones favorables:

- Por un lado, concluía la concesión otorgada a la empresa MIQRO por 25 años.
- En el marco del "Acuerdo sobre Planificación del Aprovechamiento y Utilización de Areas Forestales Tropicales", suscrito con Alemania desde 1978, se requería encontrar un área de trabajo en la que fuera posible realizar acciones a mediano y largo plazos, mediante las cuales se pudieran encontrar opciones adecuadas para el manejo de las selvas de México, con el objetivo de detener su destrucción.
- En los ejidos establecidos antes del decreto de creación de MIQRO, que son los de mayor tamaño, el aprovechamiento se realizó de manera ordenada, lo cual, aunado a la organización para la producción de chicle, permitió amortiguar la influencia de la política de cambio de uso del suelo con fines agropecuarios. Esto propicio que en dichas áreas quedaran superficies de selva suficientemente grandes y relativamente ricas en maderas preciosas.
- En estos ejidos se derivó una tradición forestal durante la vigencia de la concesión, al desempeñarse su pobladores como trabajadores de la empresa, lo cual les permitió adquirir experiencia en las tareas de extracción de trocería y manejo forestal.
- Se contaba con infraestructura caminera producto de los aprovechamientos realizados por MIQRO, lo cual disminuyó las necesidades de inversión.

Bajo este contexto se implementó el denominado "Plan Piloto Forestal", el cual estuvo cimentado en las siguientes premisas:

- Las selvas se conservarían en la medida en que fueran una alternativa económica para los campesinos que las habitan y en que los interesara en su aprovechamiento racional.
- El aprovechamiento selectivo de las selvas no constituye una alternativa económica de desarrollo a largo plazo para los campesinos.

Lo anterior implicaba como precondición, que los grupos campesinos tendrían que ser el sujeto social encargado de administración de los recursos forestales. Por otro lado también era necesario establecer un mercado para la variedad de especies de la selva.

Como áreas piloto se escogieron 10 ejidos del sur del estado, los cuales destacaban por su experiencia para organizar los aprovechamientos forestales, contar con superficies relativamente grandes de selva (entre 5,000 y 30,000 Ha) y por su interés en administrar sus propios bosques (Figura 4).

Se requirió de una estrategia de instrumentación flexible, que se fuera ajustando según se desarrollaran las actividades del plan. Se definió su orientación y las tendencias que deberían promocionarse; de antemano no todo se tenía previsto o programado. Lo importante era no perder el rumbo, ya que se buscaba ir creando las condiciones para lograr el manejo sostenido de los bosque tropicales en la región.

La estrategia de instrumentación del Plan considera las siguientes líneas de acción:

Asistencia técnica

Cambiar el papel del servicio forestal, que de ser un organismo de control y vigilancia, tuviera una función de promoción y apoyo al desarrollo de las empresas forestales campesinas. Hubo limitaciones en este sentido, ya que el servicio estaba identificado por los campesinos como un organismo de supervisión. Se requería formar un grupo técnico que tuviera apoyo político, fuese autónomo y que no tuviera limitaciones de tipo sectorial. Un grupo con experiencia para abordar los problemas de comercialización, extracción de trocería y con una base teórica sólida que le permitiera, posteriormente, desarrollar métodos apropiados para el aprovechamiento forestal en la región.

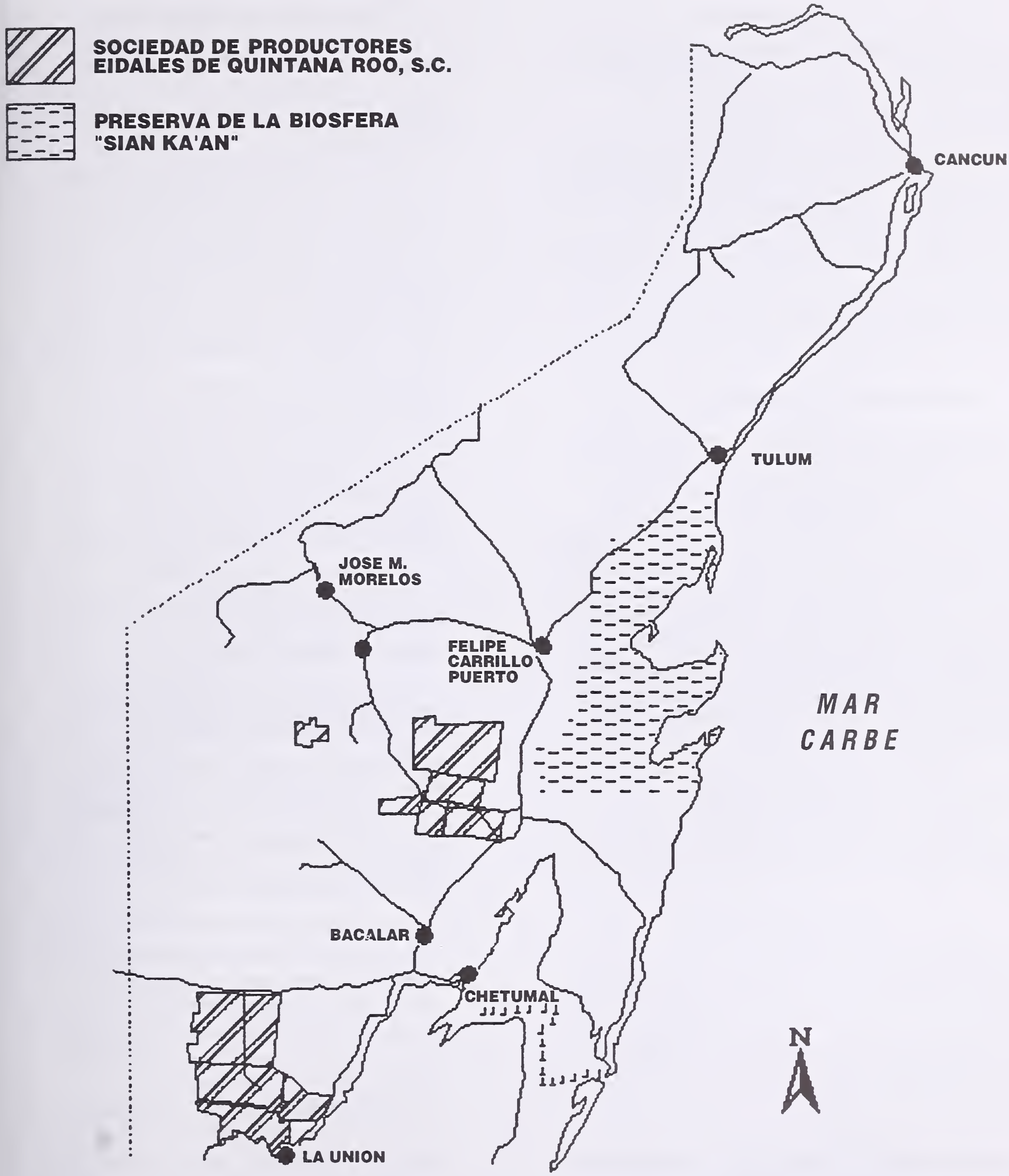

Figure 4.—Ubicacion de los Ejidos de plan Piloto Forestal

Manejo forestal

Ajustar los planteamientos de manejo forestal al grado de comprensión y organización de los campesinos, que serían los encargados de ejecutarlo, y buscar que se apropiaran paulatinamente de los aspectos técnicos. Promover la determinación de áreas forestales permanentes, el aprovechamiento de especies secundarias (duras y blandas) y la toma de decisiones en la planificación de los aprovechamientos por parte de los grupos campesinos; introducir elementos de planificación a largo plazo como ciclo de corta, diámetros mínimos de corta y áreas de corta anual.

Organización y capacitación campesina

Convertir a los campesinos en sujetos activos, con capacidad para aprovechar, comercializar y manejar sus recursos forestales. Fortalecer su capacidad de negociación y gestión. Esto solo podía lograrse en la medida en que pudieran hacer una oferta atractiva de maderas preciosas, y la negociación no fuese una acción aislada de cada ejido, sino de un frente de comercialización, que agrupara a los ejidos con mayor potencial productivo. Se tenía que lograr un proceso que se sustentara en el interior de los ejidos como respuesta a los problemas que enfrentarían, tanto en la producción, como en la comercialización.

Industria forestal

Adecuarla en forma paulatina a la diversidad de especies y al potencial productivo de las selvas.

Comercialización

Promover la venta de los productos forestales bajo el esquema de mercado libre, con la finalidad de buscar la valorización de la selva por parte de los campesinos, lo cual se lograría mediante precios suficientemente atractivos para interesarlos en el manejo del monte.

INSTRUMENTACION DEL PROGRAMA FORESTAL

Durante la ejecución del programa forestal se distinguen cuatro etapas bien definidas:

Primera Etapa (1983-1985)

- Se crea el espacio institucional para la operación de dos grupos técnicos forestales al servicio de los campesinos, en el sur y en la zona maya.
- Los ejidos con mayor potencial forestal formaron un frente de comercialización, mediante el cual lograron la venta de 2 m^3 de maderas secundarias por cada 3 m^3 de preciosas y establecieron un precio a nivel estatal para estas últimas. Estos ejidos producían el 40% de la caoba del Estado. Este grupo de ejidos se convirtió en interlocutor campesino, al ser reconocido como instancia de negociación tanto por las instituciones, como por los industriales locales.
- Las autorizaciones de aprovechamiento se condicionaron a la elaboración de programas de manejo por área de corta en tanto los ejidos se organizaban, así como a la extracción de 2 m^3 de maderas secundarias por cada m^3 de especies preciosas, para reforzar las acciones del frente de comercialización.
- Lo anterior no fue suficiente para lograr precios atractivos y la compra de un buen número de especies corrientes tropicales. En respuesta, el Gobierno del Estado compró el 49% de las acciones de MIQRO que ahora se abastecia del mercado libre, con lo cual forzó una política de comercialización y la compra de las especies corrientes tropicales.
- Aunque la empresa cumplió con la compra de especies comunes tropicales a los ejidos, no realizaba su transformación. Esto originó que se incrementaran los inventarios de trocería de estas especies. Este problema se agudizó al grado que la empresa se declaró en quiebra, perjudicando a los ejidos; lo que ocasionó que la madera cortada se pudriera en el monte y los ejidatarios perdieran el capital invertido. Esta situación obligó a los ejidos a buscar mecanismos que les permitieran asegurar la rentabilidad del aprovechamiento.

- Varios ejidos recibieron créditos para la rehabilitación de maquinaria forestal, y otros la compraron con recursos propios, lo cual permitió su capitalización.
- Las labores forestales fueron realizadas por los ejidos; desde la extracción hasta la comercialización, incluyendo la administración.
- Asimismo, se realizaron los primeros ensayos de plantaciones de enriquecimiento con especies preciosas (en las bacadillas y carriles de arrime) y se involucró a los campesinos en los inventarios.
- Se desarrolló la organización productiva de los 10 ejidos participantes en el Plan, lo cual aunado al frente de comercialización y a la compra de maquinaria de extracción, los ubicó como productores de madera en rollo y les permitió la apertura de un mercado local de la madera.
- Se despertó el interés por la administración directa de sus montes en 16 ejidos de la zona maya, con lo cual se reforzó el poder de negociación del frente de comercialización, permitiéndoles iniciarse en la administración directa del durmiente.
- Se realizaron ensayos para industrializar especies blandas y duras tropicales y las preciosas dejan de ser utilizadas para centros de triplay y se establecieron nuevas empresas productoras de chapa y triplay (Triplay del Caribe, Laguna Ocum y Chapas Finas de Quintana Roo).
- El interés de los campesinos por la actividad forestal se incrementó y los ejidos definieron áreas forestales permanentes; 250 mil hectáreas.

Segunda Etapa (1986-1987)

- Se constituyen dos Sociedades Civiles de productores, que agrupan a los 26 ejidos con mayor potencial forestal: La Sociedad de Productores Forestales Ejidales de Quintana Roo y la Organización de Ejidos Productores Forestales de la Zona Maya, con lo cual se consolidó el frente de comercialización.
- Ambas sociedades convienen con la Secretaría de Agricultura y Recursos Hidraúlicos del Gobierno Federal (SARH) la formación de sus propias direcciones técnicas forestales, integradas por el personal que formaba el grupo de apoyo técnico.
- Se obtuvo el apoyo por parte del Gobierno del Estado y del Consejo Nacional de Ciencia y Tecnología (CONACYT), para la elaboración de planes de manejo de los ejidos. Este permitió levantar los inventarios en el 50% de las áreas forestales permanentes, con lo cual se afianzó el concepto de inventario forestal como herramienta de planificación.
- Los resultados de los inventarios obligaron a realizar un ajuste en los volumenes de extracción anual de maderas preciosas, reduciendolos en un 30%. La aceptación de esta reducción por los campesinos era una clara respuesta de su asimilación del concepto de aprovechamiento sostenido.
- Los ejidos con mayor potencial forestal (Noh-bec, Tres Garantías y Caobas) deciden instalar sus propios aserraderos, mediante la obtención de créditos, como respuesta a los problemas que se derivaron de las negociaciones con los compradores de madera de los aserraderos locales, al no contar con el mercado que ofrecía MIQRO y sin la perspectiva de comercializar maderas comunes tropicales.
- Lo anterior generó problemas técnicos y administrativos para la operación de los aserraderos y en la comercialización de la madera aserrada. Sin embargo, se generaron empleos para los productores y permitieron transformar la maderas preciosas y darles valor agregado. Asimismo les generó un incremento en las utilidades por la venta de madera aserrada.

- De los ingresos obtenidos del aprovechamiento, en los ejidos se invirtieron fondos en la realización de obras de beneficio social.
- Para sufragar los costos de las direcciones técnicas forestales, los ejidos determinaron aportar una cuota por metro cúbico de maderas preciosas extraído.
- Se retoman los conceptos del Plan Piloto y se decide extenderlo al resto de la entidad y a finales 1987 el Gobierno del Estado dió a conocer su declaratoria de política forestal, en la que destacan los siguientes aspectos:
    - Se declara de interés público la creación de una reserva forestal estratégica de carácter productivo, constituida por la suma de las áreas forestales permanentes definidas por los ejidos y pequeños propietarios.
    - La promoción y apoyo para el desarrollo de organizaciones forestales campesinas con sus propias direcciones técnicas para el aprovechamiento racional de los recursos forestales.
    - La promoción y desarrollo de una industria forestal adaptada a la capacidad de producción y diversidad de especies de la reserva forestal estratégica.

Tercera Etapa (1988-1992)

- Se presentaron problemas serios de comercialización de especies comunes tropicales e inclusive existió el riesgo de volver al modelo de aprovechamiento selectivo anterior, debido al ingreso del país al Tratado General de Comercio y Aranceles (GATT), en virtud de que gran parte del mercado de esas especies, se perdió al importar caoba aserrada e inclusive triplay de sustitutos de caoba, ya que resultaba mas barata.
- La SARH y el Gobierno del Estado convinieron la creación de dos unidades de servicios técnicos forestales para apoyar a los ejidos con perspectivas de manejar sus recursos a largo plazo, y que no pertenecían a ninguna organización de productores, los cuales no tenían interés manifiesto por hacer un manejo racional de las selvas. El Gobierno del Estado adquiere el compromiso de proporcionar dichos servicios técnicos a los campesinos forestales que sufragan parte de los gastos de operación mediante el pago de una cuota.
- Se incorporan algunos pequeños propietarios al Plan y forman la Organización de Pequeños Propietarios Forestales de Quintana Roo.
- Estos ejidos y pequeños propietarios acuerdan establecer áreas forestales permanentes, con lo que se incrementa la superficie de la reserva forestal estratégica productiva a 362,000 Ha.
- En las áreas organizadas se concentró el 85% de la producción forestal del Estado de Quintana Roo.
- Para apoyar la planificación de las cortas y las labores silvícolas, se desarrolló un sistema de análisis de resultados de los inventarios forestales que permite mapear por computadora los principales parámetros forestales de cada una de las especies, se pueden localizar rodales y ubicar las existencias cortables.
- Con apoyo de técnicos, en una de las organizaciones de productores concluyeron los inventarios forestales y en otra se avanzó un 70%.
- Se iniciaron acciones para promover el uso y fomento de la fauna silvestre como un recurso con un alto potencial, con la intención de incorporar a los productores a su manejo.
- Como respuesta a los problemas de comercialización de maderas, ha habido intentos de formar sociedades entre empresas establecidas y los ejidos, que ha enfrentado problemas por el interés de los ejidos de dar un mayor valor agregado a su materia prima.
- Lo anterior reforzó la tendencia de aserrar la caoba en los ejidos e iniciar el establecimiento de talleres de carpintería, con los

cuales se generaron nuevas fuentes de empleo y se da mayor valor agregado a la madera mediante la fabricación de muebles.

- Paralelamente se comienza a incorporar tecnología adecuada para la transformación de maderas comunes. Dicha incorporación permitió que en dos ejidos se iniciara la elaboración de muebles y juguetes didácticos de maderas comunes.
- Se inició un estudio de estimación de crecimiento el cual permitirá introducir al cálculo de posibilidad anual, los datos de mortalidad y crecimiento
- En 1990-91 se promueve la transferencia de la experiencia de Quintana Roo a la región de X-Pujil, Camp, en la cual se ubica la Reserva de la Biósfera de Calakmul.
- La Sociedad Civil de Productores realiza acciones de promoción para la apertura de mercados internacionales, logrando comercializar con el Reino Unido cuatro remesas de madera.
- Finalmente, otro aspecto que impactó en el desarrollo de los ejidos, fue el acceso a los mercados ecológicos, al otorgarse por primera vez en 1992 un certificado ecológico de manejo sostenible para 2 ejidos.

Cuarta Etapa (1993-1994)

- Se cuenta con un equipo de apoyo técnico integrado por 32 elementos, los cuales conforman cuatro direcciones técnicas forestales que trabajan en el contexto de las organizaciones de propietarios forestales, los cuales en promedio cubren 15,000 Ha cada uno (2 comunidades ejidales).
- Se ha desarrollado una experiencia en plantaciones de enriquecimiento en las áreas aprovechadas.
- Se aprovecha un total de 12 especies y se está incrementando el número. Esto significa que será necesario experimentar alternativas silvícolas y estudiar los costos de operación.
- Se ha integrado una base de información de inventarios para manejo forestal, asímismo se está formando una red de parcelas permanentes que permitirá estimar de manera más precisa el potencial de aprovechamiento de las selvas.
- Se reciben apoyos y financiamiento de los Gobiernos Federal y Estatal y de diversas instituciones y organizaciones no gubernamentales internacionales como la Overseas Development Agency (ODA), la Fundación McArthur y la World Wild Fundation (WWF), para el desarrollo del Plan.
- En las cinco sociedades de productores y otros ejidos no organizados, se han definido 502 mil Ha como áreas forestales permanentes (Tabla 2).
- Durante 1993 se otorgaron tres certificados ecológicos de manejo sustentable, y este año cuatro.
- Recientemente el Gobierno del Estado, dada la importancia de los recursos forestales en la entidad, decide la creación

Tabla 2.—Superficie del área Forestal Permanente (AFP)

ORGANIZACION	No. DE EJIDOS	SUPERF. TOTAL (ha)	AFP
Soc. de Prod. Forestales de Q. Roo	10	289.204	108,650
Org. de Productores Forestales de la Zona Maya	18	385,530	163,000
Soc. de Pueblos Indigenas Forestales de Q. Roo "Tumbem Cuxtal"	9	90,112	31,916
Org. de Ejidos Forestales de Q. Roo "Chaktemal"	9	199,720	85,000
Zona Norte	5	236,080	90,000
Otros Ejidos	13	104,524	23,600
TOTALES	64	1,305,570	502,166 (38%)

de una instancia encargada de instrumentar la política forestal del estado, y se incorporan nuevas líneas de acción: el apoyo a la organización de las cooperativas chicleras y la incorporación del manejo de fauna silvestre, así como el ecoturismo como actividades alternas al aprovechamiento forestal maderable.

- Se está promoviendo un proceso de descentralización y transferencia de las tareas de los servicios técnicos forestales a las propias comunidades, con la finalidad de que éstos sean más integrales. Para ello, se ha integrado personal de las comunidades a las direcciones técnicas forestales.

IMPACTOS DEL PROGRAMA FORESTAL

Ha transcurrido más de una década de haber iniciado actividades el programa forestal, las cuales han tenido un impacto significativo, que se refleja en diferentes aspectos:

- La tendencia hacia la destrucción de la selva en las áreas en que ha incidido el programa se ha reducido. Prueba de ello es la determinación de 502 mil Ha como áreas forestales permanentes, que representan el 38% de la superficie total de los ejidos participantes.

- Se ha avanzado considerablemente en la conservación de las selvas, al convertirla en una alternativa económica de desarrollo para los grupos campesinos que las habitan.

- Se ha desencadenado una tendencia hacia el aprovechamiento racional sostenido de las selvas del Estado en las organizaciones forestales campesinas.

- Al inicio de la ejecución del plan, en 1983, se aprovechaban en las selvas del Estado 40 mil m^3 anuales de especies preciosas. Como resultado de los inventarios forestales, fue necesario reducir los volúmenes a 13 mil m^3. Esto significó un impacto económico en los ejidos, al causar una baja en los ingresos, efecto que se amortiguó con la instalación de los aserraderos ejidales, con lo que se crearon empleos y se agregó valor a la madera.

- La idea de incorporar a los productores a las actividades de aprovechamiento forestal ha rendido frutos, 6 mil familias campesinas se han beneficiado y tienen un concepto de desarrollo rural compartido a partir del aprovechamiento racional de los bosques (Tabla 3).

- Los ejidos que se han organizado para el manejo sostenible de sus selvas comprenden el 80% de las selvas comerciales del estado (Figura 5).

- La obtención de certificados ecológicos son un estímulo a los productores por el buen manejo de sus recursos y son la llave de entrada a los mercados internacionales, que actualmente se limitan al Reino Unido, Estados Unidos de América y Japón, y por otro lado avalan los resultados del Programa Forestal.

Tabla 3.—Estructura Social de las Organizaciones Campesinas

ORGANIZACION	No. DE EJIDOS	No. DE EJIDATARIOS	SUPERF. TOTAL (ha)
Soc. de Prod. Forestales de Q. Roo	10	2,084	289,204
Org. de Productores Forestales de la Zona Maya	18	2,791	384,530
Soc. de Pueblos Indigenas Forestales de Q. Roo "Tumbem Cuxtal"	9	659	90,112
Org. de Ejidos Forestales de Q. Roo "Chaktemal"	9	1,173	199,720
Zona Norte	5	1,529	236,080
TOTALES	51	8,236	1,200,646

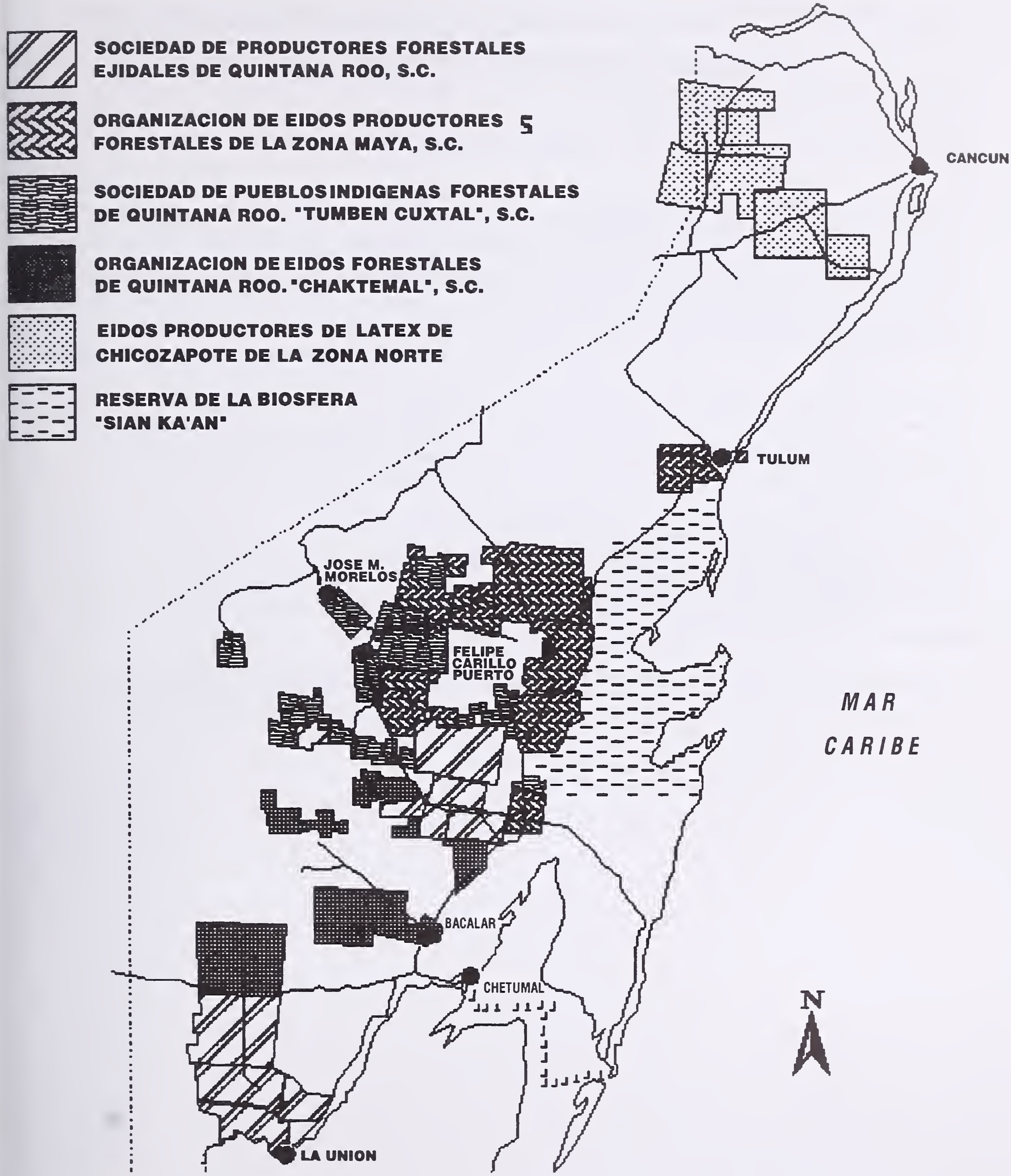

Figure 5.—Distribución de las Organizaciones de Productores

PERSPECTIVAS

- La consolidación de la reserva forestal estratégica productiva, permitirá planificar el desarrollo de una industria forestal estable y adaptada a la capacidad de producción de la reserva.
- Las empresas ejidales están incorporando la tecnología del secado y dimensionado de maderas duras, como alternativa para tener acceso al mercado. Se tienen perspectivas de transición de la organización ejidal a una forma más empresarial de administrar el negocio forestal.
- Se ha incorporado un mayor número de especies al mercado. De continuar esta tendencia, permitirá realizar un manejo más sostenible del recurso y se generarán mayores beneficios.
- Existe un interés manifiesto del Gobierno del Estado de Quintana Roo en torno al desarrollo integral de la entidad, y los recursos forestales constituyen la alternativa más viable para lograrlo.
- Por otro lado, las actividades del "Acuerdo sobre Planificación del Aprovechamiento y Utilización de Areas Forestales Tropicales", suscrito con el Gobierno de Alemania han significado un importante apoyo para el logro de los resultados alcanzados. Actualmente se está tramitando una prórroga para continuarlo por tres años más con la finalidad de trasferir en su totalidad la experiencia del proceso.
- Finalmente, puede afirmarse que en el Estado de Quintana Roo, se ha avanzado considerablemente en la conservación de las selvas, al convertirlas en una alternativa económica de desarrollo para los grupos campesinos que la habitan. Simultáneamente se ha avanzado en el desarrollo de un concepto de manejo racional sostenido de la selva.

Una panorámica del proyecto demostrativo sobre manejo de ecosistemas Chattooga

David C. Cawrse[1]

Resumen.—El proyecto demostrativo sobre manejo de ecosistemas Chattooga se inició en 1991 como resultado de una petición desarrollada por una coalición de cinco grupos ambientalistas preocupados en la biodiversidad de la cuenca del Rio Chattooga. La Región Sur del Servicio Forestal, también ha reconocido éste como un ecosistema único, y ha implementado un proyecto a tres años sobre manejo de ecosistemas. El manejo de esta cuenca es muy complejo, ya que es administrada por tres administradores de distrito, cada uno en un bosque nacional diferente ubicados en diferentes estados. El objetivo principal de este proyecto es desarrollar un alternativa integrada y ecológica para manejar la cuenca Chattooga. Esto incluye el desarrollo de las más recientes herramientas e información que permitan tomar mejores decisiones. Algunas de las herramientas incluyen Sistemas de Información Geográfica y clasificación de ecosistemas; entre la información requerida se encuentran datos sobre calidad de agua y biodiversidad, así como las espectativas de la gente para el área. Esas herramientas e información ayudarán a los manejadores a tomar mejores decisiones, mientras manejan adaptativamente los bosques nacionales. Varios de los proyectos que se están realizando incorporan este enfoque ecológico. Este enfoque se encamina a satisfacer las demandas de la sociedad para que los bosques sean tanto más diversos, sanos y bellos, como útiles.

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Manejo de ecosistemas aplicado a áreas de piñon-juniperus/sagebrush en el Norte de Nuevo, Mexico

Daniel L. Rael, Mark T. Lujan[1], Palemón A. Martinez y Brett T. Coleman[2]

Resumen.—Conceptos de manejo de ecosistemas fueron usados para describir la condición futura deseada de terrenos del sistema nacional forestal, dentro del distrito Tres Piedras en el Bosque Nacional Carson. La condición no satisfactoria de la cuenca, el tipo de vegetación piñon-juniperus/sagebrush, y los límites de la cuenca, definieron el área de manejo de la parte inferior de la unidad Petaca. Un planteamiento de la condición deseable para el área, se produjo usando consideraciones ecológicas, económicas y sociales. La participación del público fue activamente solicitada y promovida. Se llevaron a cabo asociaciones entre usuarios del recurso e investigadores.

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Manejo, conservación y protección forestal en el Desierto de los Leones

Jesús Vázquez Soto[1]

Resumen.—En este trabajo se analiza el manejo, la conservación y la protección forestal del Parque Cultural y Recreativo Desierto de los Leones (PCyRDL), en el que se consideran aspectos relacionados con la vegetación forestal, su sanidad y su declinación. Se revisan los sistemas silvícolas que pueden ser aplicables; con base en un inventario forestal se proyecta un plan de manejo, considerando aspectos referentes al saneamiento, la reacción del bosque, el vigor de los árboles, la presencia de plagas, la fenología forestal, la regeneración del bosque, las frecuencias diamétricas, las asociaciones vegetales, los requerimientos ambientales, la diversidad florística y su conservación, la relación entre fases serales y los mantos freáticos respecto al bosque. En 1986 se observó los beneficios de los trabajos de limpia/saneamiento al registrar la diferenciación de los primordios, produjo no sólo crecimiento vegetativo, sino también una buena producción de semillas, lo que demuestra la reacción positiva del bosque al inicio de un tratamiento que era requerido.

INTRODUCCIÓN

Desde hace unos 2,000 años se empezaron a tener asentamientos humanos importantes en la cuenca de México, mientras que la ciudad de México se fundó en el año 1325.

El Parque Cultural y Recreativo Desierto de los Leones (PCyRDL), está íntimamente ligado a la vida activa de la Zona Metropolitana de la Ciudad de México y reviste una gran importancia dentro de la Zona de Conservación Ecológica de la misma, especialmente como una área de recreación al aire libre, ofreciendo múltiples atractivos, tanto de recursos geológicos, hidrológicos, vegetales y forestales en particular, al igual que de recursos faunísticos e históricos de gran interés.

A pesar de su gran importancia y de su fácil acceso, el PCyRDL tiene un historial caracterizado por un cúmulo de negligencias, abusos y abandonos en relación a la conservación y aprovechamiento de sus diversos recursos. Sin embargo, tal parece que lo más grave lo representa la carencia de un plan de manejo que contenga objetivos claros respecto a fines bien definidos para utilizar el Parque como área recreativa y cultural, que lo disfrute la población de la Zona Metropolitana de la Ciudad de México.

ANTECEDENTES

El Parque Cultural y Recreativo Desierto de los Leones (PCyRDL) ocupa 1,529 ha, asignándose esta superficie al Departamento del Distrito Federal para su administración y manejo a partir de 1983. El área se distribuye entre los 2,800 msnm y llega a más de 3,800 msnm. En el área abundan las rocas andesíticas, los productos tobosos, brechi-formes y detríticos. Los terrenos son accidentados y en tres de las cuatro series de suelos estudiadas se presentan cambisoles; en la cuarta serie hay andosoles y en esta serie los suelos son poco

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profundos y pobres en fósforo aprovechable. Sin embargo, los suelos profundos son abundantes, bien drenados y ricos, húmedos generalmente durante todo el año y son moderadamente ácidos.

A 3,200 msnm llueve unos 1,300 mm , que se distribuye en 100 o más días con lluvia apreciable. Abundan los días nublados y los días con rocío; los meses secos son más de cuatro. Casi todos los años hay nevadas y las temperaturas medias anuales varían de 7 a 15 °C en promedio, mientras que las oscilaciones diurnas de la temperatura puede ir de 11 a 16 °C.

En 1913 , una Misión Forestal Francesa rindió un informe sobre el estado que ofrecían los bosques del Desierto de los Leones, declarando que se trataba de un oquedol regular entresacado, que no había recibido ningún tratamiento, que eran bosques decrépitos que reclamaban una atención inmediata.

En el año de 1913 se determinó un volumen por hectárea de 562.8 m^3 y de ese volumen el 99.7% eran maderas resinosas; mientras que en el año 1983, 70 años después, el volumen del mismo bosque se fijó en 401.768 m^3/ha , esto es, el 71.38% del volumen determinado en 1913. Asimismo, en 1983 el 96% del volumen corresponde a maderas resinosas, lo que implica que en el período señalado ganaron terreno las especies latifoliadas.

Para 1983 el 77% del volumen estaba sano, mientras que el resto presentaba diversos tipos de daños. Las coníferas sanas - oyameles y pinos - cubrían el 76% del volumen total de resinosas. Las dos especies de coníferas más importantes en estos bosques son el *Abies religiosa* (oyamel) y el *Pinus hartwegii*. Del volumen total de la primera especie citada estaba dañado el 28%, mientras que en la segunda especie el 19% del arbolado presentaba daños, principalmente por ataques de descortezadores.

Durante 1983 abundaban individuos de huauahchichic (*Garrya laurifolia*), encinos (*Quercus* spp.), capulines (*Prunus* spp.), ailes (*Alnus* spp.), madroños (*Arbutus* sp.), tepozanes (*Buddleia* spp.) y el palo amarillo (*Berberis* spp.), entre otras especies bien caracterizadas de las fases secundarias en el proceso secuencial del tipo de bosque como el que estamos tratando.

Los ataques de plagas y enfermedades, los daños por vandalismo y mal uso de los recursos, la creciente presión del público visitante, junto con los probables daños causados por la contaminación, originaron efectos sinérgicos que dieron lugar a graves síntomas de declinación forestal, debilitamiento y mortandad de árboles - daños sobre el árbol más importante de este Parque, que es el oyamel - hasta culminar en la presencia de 274 ha de "cementerios" de árboles, como el caso más grave.

LA VEGETACION FORESTAL

Los tres tipos principales de vegetación arbórea se distribuyen como sigue, dentro de los límites del PCyRDL: entre los 2,600 y los 2,800 msnm hay bosques con *Pinus montezumae*, *P. pseudostrobus* y *P. leiophylla*. De los 2,800 a los 3,200 msnm hay bosques de oyamel con pinos muy escasos. De los 3,200 msnm hasta el límite altitudinal máximo hay bosques de pinos, con predominancia de *Pinus hartwegii*. Hay algunas partes donde el bosque de oyamel es denso, con penumbra en los niveles inferiores y con un desarrollo limitado de los estratos arbustivo y herbáceo con abudantes musgos, líquenes y macromicetos.

El oyamel y el oyametal, son la especie arbórea y el bosque más bello y majestuoso que es posible encontrar en el PCyRDL, pero, igualmente, son los que presentan problemas muy preocupantes.

Se ha sugerido, teóricamente, que a la destrucción del bosque puro de oyamel debería seguir una fase de gramíneas amacolladas (zacatones de *Stipa*, *Muhlenbergia* y *Calamagrotis*), fase a la que seguiría otra arbustiva, con especies de *Juniperus*, *Baccharis*, *Quercus*, *Arbutus*, *Alnus* y *Salix*, entre otros. Es posible, también, encontrar manchones puros de encinos (*Quercus*) de evidente carácter secundario, especialmente en aquellas áreas donde es más fuerte la presión de los visitantes.

El clima del área es definitivo en el proceso evolutivo a que están sujetas las especies vegetales del PCyRDL, por lo que considerando que las fluctuaciones climáticas son grandes en la cuenca, se ha postulado que si los valores medios de la precipitación se localizan entre 600 a 870 mm anuales, aparecerían dos tipos de clima: el templado moderado lluvioso al sur de la cuenca (donde se localiza el Parque) y el seco estepario al norte de la misma.

También se ha hecho notar que durante el Pleistoceno y el Holoceno, períodicamente se abatió la temperatura en la cuenca y como respuesta hubo cambios en la vegetación del Ajusco; en los períodos con clima frío y seco las montañas se cubrían con un pastizal alpino, pero en tiempos de clima frío y húmedo se presenta un bosque de pinos y gramíneas; pero, si las condiciones del clima se vuelven más benignas, tendiendo a templado-húmedo, la riqueza florística aumenta y se registran *Abies*, *Quercus*, *Tilia*, *Taxus*, *Liquidambar* y *Picea*. Los dos últimos han desaparecido de la vegetación natural de la cuenca; el último hace unos 10,000 años, creyéndose que la causa fue una disminución paulatina de humedad y que un fenómeno de desecación paulatina puede también afectar en el futuro al bosque de *Abies religiosa*.

LA SANIDAD FORESTAL

Los bosques del sistema montañoso de la Sierra de las Cruces, que es donde se localiza el PCyRDL, han sufrido diversos tipos de daño derivados de 47 años de veda forestal, abandono de las áreas, de falta de aprovechamientos forestales organizados, de carencias de campañas adecuadas para su control y de condiciones específicas en áreas cuya propiedad se halla en litigio. Los señalamientos anteriores son los principales en relación con la sanidad forestal en el área. Sin embargo, los gusanos defoliadores (*Evita hyalinaria* sobre el oyamel) los escarabajos o mayates descortezadores (*Dendroctonus adjunctus*, *D. mexicanus*, *Ips bonanseai*, *Cnathotrichus Sulcatus* y *C. deleoni*), sobre los pinos han originado daños.

A las puntas y ramas de los oyameles las pueden atacar especies de *Hylurgops y Scolytus*, mientras que *Pseudohylesinus variegatus* se presenta como descortezador secundario de los oyameles. Algunos de los hongos que es posible encontrar pertenecen a los géneros *Ceratocistis sp.*, *Alternaria*, *Pythium* y *Verticillum*, mientras que en el follaje de los árboles es posible encontrar especies de *Fusarium* y *Armillariella*.

Otras plagas son los chupadores, especies de *Cinara* y los defoliadores *Choristoneura*, *Eucosma* y *Rhyaciona*, además de los parásitos como el muérdago enano (*Arceuthobium vaginatum*) y la lorantácea (*Arceuthobium abietis-religiosae*) sobre el oyamel. En el cedro blanco (*Cupressus linleyi*) es posible encontrar un descortezador del género *Phloesinus*.

La abundancia de factores causantes de daños en los bosques del sur del Distrito Federal hizo que para 1983 el problema de conservarlos sanos fuera de gran magnitud, en un ambiente donde privaban un gran número de opiniones acerca del origen y de la forma probable para controlar y atacar los daños al bosque, y entre todas esas ideas dominaban los "enfoques naturalistas", que señalaban que los árboles se debían adaptar a las características de este Parque, pero que no señalaban con claridad cuales eran unas y cuales las otras, todo eso en razón de grandes lagunas en el nivel de conocimientos técnico-científicos básicos en relación a los bosques del Parque, insistiendo en que los daños los causaba *Phytophthora cinnamomi*, cuando nunca probaron la existencia de ese hongo, o bien que los problemas los causaba la lluvia ácida

LA DECLINACIÓN FORESTAL EN EL PARQUE

A fines de los años setenta se notó que los patrones de mortalidad de los árboles no correspondían a los agentes de deterioro y destrucción ya sufridos y conocidos en el Parque.

Los síntomas de declinación y sus intensidades varían de acuerdo con las masas forestales, los tipos de bosques, las especies y las localidades. Siempre hay decoloración en los árboles, pérdida de agujas y de hojas, disminución en la producción de biomasa (tanto radical como área), de disminución del crecimiento anual, de caída prematura de agujas adultas en las coníferas y aún de hojas verdes, de aumento en la susceptibilidad al ataque de insectos y enfermedades, de caída de retoños y de formación de copas distorcionadas, culminando generalmente en la llamada "muerte descendente" de los árboles, pudiendo ser éstos indistintamente dominantes o dominados en la masa arbórea.

La declinación forestal sufrida en los bosques del PCyRDL coincidió con el deterioro de bosques de coníferas en más de 15 países, hasta donde sabemos. Esos fenómenos son conocidos desde

largo tiempo y sus causas son de una gran variabilidad. Así, cuando los abetos se empezaron a secar en 1960 en Mount Mitchell (oeste de Carolina del Norte) se sospechó y culpó en primer lugar al pulgón lanígero del bálsamo, sin que ese áfido tuviera ninguna culpa. Se sabe del amarillamiento letal de la palma de coco, del declinamiento del peral, el amarillamiento del Aster y de los amarillamientos, clorosis internerval, formación de escobas de bruja y necrósis progresiva de algunas ramas, hasta causar la muerte en el paraíso (Melia azedarach) caso en el que el responsable es un microplasma.

El problema de la declinación forestal en el PCyRDL se ha visto, en ocasiones en forma por demás simplista, al postular que los vientos del norte a su paso por el área urbana y algunas zonas industriales se cargan de contaminantes, los que son descargados sobre los bosques del sur de la cuenca de México. Al igual que en varios países europeos, podemos afirmar que la declinación forestal no la podemos atribuir a la contaminación atmosférica como causa única y que siempre debe considerarse el efecto combinado de ella con sequías, heladas, hongos, insectos, disminución de resistencias al frío y a deficiencias nutricionales y en nuestro caso los factores de disturbio que causan los aprovechamientos indiscriminados, no planeados, de recursos asociados como el agua y diversos tipos de vegetales. Sin embargo, el origen de gran parte de los problemas se encuentran en la no implantación rigurosa de un Plan Maestro, que debe incluir un Reglamento del Parque, un Programa de Manejo Integral de Subcuencas y sobre todo un Programa de Manejo Forestal adecuado a los objetivos del Parque Cultural y Recreativo.

LOS OBJETIVOS DEL MANEJO FORESTAL

Los objetivos de un programa de manejo forestal en un área dada, pueden variar desde la producción de diversos tipos de madera, hasta el mejoramiento de las facilidades para la recreación al aire libre, pasando por la producción y regulación de recursos acuíferos y ofrecer refugio y sostén a la fauna silvestre, sirviendo también como área de protección ecológica natural a un gran conglomerado humano y, todos esos tipos de producciones obviamente precisan estructuras forestales muy diferentes entre sí.

Conviene señalar que algunos objetivos simples, como es la producción de madera, precisan una estructura forestal sencilla pero que sea eficiente. Por el contrario, algunos objetivos complejos, como los que representan e incluyen usos múltiples de los recursos naturales requieren el mantenimiento de estructuras forestales complejas y diversas, las que en ocasiones pueden resultar no tan eficientes para algún fin particular, tal como hemos encontrado en el PCyRDL.

En nuestra área de trabajo interactúan varios subsistemas principales, como son el forestal, el de fauna silvestre, el de uso recreacional y de desarrollo y el hidrológico, cuya interacción produce y afecta a la vegetación, a la fauna y a las condiciones del suelo que determinan la cosecha y la calidad de los bienes y servicios. Eso significa que para implantar un plan de manejo forestal integral, éste debe tener sentido práctico en cuanto a la ordenación forestal pero sin olvidar los aspectos de sensibilidad social.

LOS SISTEMAS SILVÍCOLAS APLICABLES

Desde hace mucho tiempo se ha creído que impidiendo cualquier tipo de aprovechamiento forestal se iban a conservar los bosques, sobre todo no permitiendo la apertura de caminos, con la convicción, errónea, de que en esa forma conservaríamos **"vírgenes"** las zonas forestales. Sin embargo, es nuestra convicción que **más que virginidad forestal** lo que debemos buscar es que **nuestros bosques logren un estado vigoroso**, en buenas condiciones sanitarias, lo que les permitirá regenerarse con facilidad e indefinidamente.

Al manejar bosques dedicados a la recreación es común que se busque la máxima cobertura arbolada posible, olvidando a veces que es necesario buscar las distribuciones de clases de edad, o su equivalencia en clase diamétricas, que se ajusten a las distintas clases de estación que es posible encontrar en el bosque, localizándolas y delimitándolas en el terreno mismo, sea como rodales, coetáneos o decidiéndose por mantener un bosque irregular. En cualquier forma del bosque debe ser inspeccionado minuciosamente para localizar y señalar los árboles que deben extraerse (aquellos sobremaduros, maduros, plagados, enfermos, dominados, con daño físico, entre otros) para cortarlos en grupos o aislados, sea anual o periódicamente.

De todo lo anterior, se deduce que para el caso del PCyRDL recomendamos se aplique el sistema silvícola de selección, debiendo dejar en pie árboles en número y posibilidades biológicas que aseguren la generación del bosque, no importando tanto su incremento. Debe recordarse que la edad a la que se extraigan los árboles sea superior a aquella en la que se logra la culminación del incremento anual del área basal del bosque; esa es la edad a la que los árboles producirán su crecimiento acumulativo medio máximo. Algunos destacados investigadores forestales nos señalan que la regeneración del oyamel se favorece a medida que aumenta la intensidad de la luz, hasta un grado de cobertura de 0.74, por lo que debe procurarse no ir demasiado lejos con el aclareo, ya que la regeneración del oyamel es antes que nada un problema de dosificación de la luz y explicándonos así las dificultades que presentan las plantaciones de oyamel si se efectúan a cielo abierto.

Hasta hace poco tiempo en grandes porciones de este Parque hubo una notable predominancia de árboles maduros y sobremaduros; con una representación inadecuada de las clases de edad más jóvenes y una casi completa ausencia de renuevos y brizales.

Igualmente, en algunas partes del bosque se presentaban estructuras forestales muy distintas entre sí; desde el oyamel alto pero con un solo estrato arbóreo y uno herbáceo, o sea una estructura atractiva para los legos pero poco adecuada para la regeneración natural del bosque. Otra estructura forestal interesante ofrece oyameles jóvenes y vigorosos, en edad de regenerarse, pero con carencias de espacio vital para su regeneración.

Después de los trabajos de limpia y saneamiento podemos encontrar una estructura que ha permitido una respuesta adecuada del bosque. Este se halla bien espaciado y en condiciones de recibir apropiadamente las semillas, y lo que hay que buscar en el momento en que haya que reducir el área basal total aumentando el número de árboles, incluyendo una reducción de la producción fotosintética, una proporción respiratoria mayor en relación a la fotosíntesis, una mayor demanda de agua y nutrientes así como un insuficiente desarrollo radicular.

Algunos autores recomiendan que para mantener uniforme la densidad de un rodal se regule el espaciamiento en función de la altura, siendo necesario recordar que el diámetro es afectado grandemente por la densidad de la masa, mientras que la altura es bastante independiente, por lo que se han correlacionado la altura de los árboles con el sitio y la edad. Por otra parte, al utilizar los datos de diámetro y altura, normalmente obtenidos en trabajos de inventario forestal, debe hacerse con sumo cuidado, ya que en ellos se reflejarán distintos patrones de crecimiento según las diferentes calidades de estación del bosque, por lo cual es preferible, cuando sea posible, utilizar índices de sitio, que son más sensibles que otros datos. Además, debemos recordar que después de la calidad de estación, la densidad del rodal es el factor más importante en cualquier plan de manejo y es también de fácil y correcta determinación, además de fácilmente manipulable.

Siempre conviene tener un patrón con el cual comparar valores similares de masa arbóreas individuales para determinar las densidades de esas masa, así resulta útil graficar la relación número de árboles y su diámetro promedio. Se debe recordar que el número de árboles puede variar sin afectar a la densidad y el crecimiento es afectado por las entresacas. Además, para una densidad dada el número ideal de árboles por unidad de área es una función constante del cuadro de la masa, independientemente de la calidad del sitio.

CONCLUSIONES

Diversos factores de disturbio y destrucción de la vegetación, especialmente de la forestal, han actuado intensamente durante mucho tiempo en la cuenca de México. Ya hace largos años que los bosques del área que comprende el ahora Parque Cultural y Recreativo Desierto de los Leones fueron considerados como decrépitos y que urgía fueran atendidos a través de un plan de manejo forestal, que tomara en cuenta los aspectos técnicos, además de los de protección natural y sociales involucrados en sus objetivos.

En el año de 1983 se pudo identificar el grave problema que amenazaba al PCyRDL, cuando se determinó que el volumen arbóreo existente equivalía apenas al 71.38% del volumen que se había registrado 70 años antes. También se vió que las especies latifoliadas estaban ganando terreno y que solo el 77% del volumen de madera estaba sano.

Hasta 1983 el ciclo de vida y muerte siempre presente en los bosques, que son agrupaciones vivas, se había visto como lo que es un fenómeno natural, expresado como muerte de árboles en tramos o lunares en los bosques, en función de sequías, de enfermedades, de ataques de insectos o de algunas combinaciones de factores naturales.

El equilibrio de los bosques templados es dinámico y solo relativo, independientemente de las interferencias humanas. Se puede hablar de la reproducción natural de algunas especies, pero la regeneración del bosque es un poco más complicada, especialmente cuando el problema se encuentra en áreas que han sufrido poco o ningún disturbio.

Los huecos que dejan al morir los árboles, aisladamente o en grupos, juegan un papel muy importante en el proceso de regeneración. Ahí las especies intolerantes responden más rápidamente que las tolerantes, las que pueden ser temporal o permanentemente suprimidas.

La regeneración de los bosques "vírgenes" templados se ajusta a la "teoría de los mosaicos", que nos han enseñado los clásicos de la Dasonomía y así, cuando la generación actual de árboles muere la composición de la masa cambiará y una nueva combinación de dominantes tomará el lugar de la actual, ya que ninguna combinación de especies está en equilíbrio permanente, indefinido, con su medio.

En grandes porciones del Parque Desierto de los Leones había -y hay- una preponderancia de árboles maduros y sobremaduros, además de una notable ausencia de renuevos y brinzales, aunque también es posible encontrar masa coetáneas que indican disturbios fuertes, cuya existencia no hace mas que confirmar la "teoría de los mosaicos".

La escasa regeneración de los oyameles en el PCyRDL es preocupante y parece indicar un cierto proceso de cambios en el bosque, los que podrán ser cíclicos en función de que tan "vírgen" sea el bosque, pero si la comunidad sufrió alteraciones en el pasado alguna de las combinaciones de especies actuales será parte de un proceso normal -no cíclico- del desarrollo sucesional hacia un clímax estable.

Al final de la década de los setenta la declinación y la decrepitud de los bosques aquí citados se tornaron graves. Para 1983 se determinó que era necesario cortar y extraer 200,000 metros cúbicos de maderas dañadas y muertas del área del Parque, como producto de la alteración de las condiciones naturales, originada en la falta de manejo forestal, además de interferencias humanas, ya que el bosque todavía espera que se regenere a si mismo, modificando los substratos, las espesuras y las estructuras donde debe hacerlo. La interacción de los subsistemas que inciden sobre la vegetación, la fauna y los suelos precisan ser mejor conocidos y delimitados en el propio terreno, especialmente el hidrológico, puesto que su influencia es muy importante para la vida de los bosques del Desierto de los Leones.

En 1984 se determinó que lo primero era limpiar y sanear este Parque y en 1985 se iniciaron esos trabajos, además de tareas de prevención y control de erosión, de reforestación y de manejo integral de subcuencas construyendo presas filtrantes de varios tipos: piedra acomodada, gaviones y morillos, además de "tinas ciegas".

Debemos recordar que en condiciones normales una operación cuidadosa requerirá varios cortes para remover una masa forestal vieja y establecer una nueva, puesto que el crecimiento durante un período en relación con otro no es uniforme, ya que los ciclos climáticos son factores reversibles. Otros factores son los oleados de mortalidad de árboles debidos a diferentes causas. Las cortas mismas causan disturbios de considerable impacto, induciendo mortalidad o provocando una aceleración del crecimiento.

El método silvícola empleado es la selección por grupos, con aclareos por lo alto, con cortas sucesivas y por grupos o bosquetes, recordando siempre que por ahora la composición y la estructura por categorías diamétricas se volverán mucho más importantes que un diámetro mínimo de corta.

Tomando como base un buen inventario forestal pudimos proyectar un plan de manejo determinando las intensidades relativas del saneamiento; la reacción del bosque; el vigor de los

árboles; la presencia de plagas; la fenología forestal; la regeneración del bosque y sus crecimientos; las frecuencias diamétricas y su importancia en las estructuras; la correlación entre diámetros y alturas; las asociaciones vegetales y su evolución; los requerimientos ambientales del bosque; la diversidad florística y su conservación, además de los recursos asociados; la relación entre fases serales y los mantos freáticos, y en relación con el bosque.

En el PCyRDL es posible encontrar bosques muy ricos, verdaderamente exuberantes, mientras que otras partes sostienen bosques jóvenes y vigorosos, lo que nos convence que estamos muy lejos de que esos bosques desaparezcan, pero que si precisan ser atendidos bajo estricto rigor técnico, que sea bien seleccionado y analizado, haciendo una planeación eficiente de la infraestructura vial y de turismo, de la extracción de maderas y de la imprescindible planeación financiera que permita selecciones tecnológicas que aseguren operaciones eficientes, silvícola y económicamente.

Fue muy grande la satisfacción que sentimos cuando en el invierno de 1986 palpamos las bondades de los trabajos de limpia/saneamiento al ver que la diferenciación de los primordios iba a producir no sólo crecimiento vegetativo sino también una buena producción de semillas, lo cual era una prueba palpable de la alentadora reacción del bosque al inicio de un tratamiento que mucha falta le hacía.

Finalmente, es muy grato citar que en 1989 un grupo de personas representativas de los sectores social y privado, manifestaron su interés en participar en un esfuerzo concertado con el Departamento del Distrito Federal, en un programa de regeneración y desarrollo del Parque Cultural y Recreativo Desierto de los Leones a fin de preservar esta área de la Ciudad de México y desarrollar programas que tiendan a mejorarlo en una multiplicidad de áreas, proponiéndose en consecuencia, la constitución de un fideicomiso, a través del cual se lleve a cabo la recepción de aportaciones que terceras personas realicen, a objeto de complementar y fortalecer los esfuerzos del sector público para la regeneración integral de este Parque, y que funja además como un mecanismo que mediante la conjunción de esfuerzos y opiniones, coadyuve a la identificación de prioridades y determinación de programas y proyectos de desarrollo del Parque a los cuales se apliquen dichas aportaciones y así lograr la mayor transparencia posible en su adecuada utilización, en la inteligencia de que los aludidos programas y proyectos serán los que en ejercicio de sus atribuciones proponga el Departamento del Distrito Federal, ya que el fideicomiso es fundamentalmente un medio de participación de todos los sectores de la población.

Bases téchnicas y sociales para la elaboración del Plan Maestro de Manejo de la Cuenca de Pátzcuaro INIFAP-INI-Subcomité de Solidaridad

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Resumen.—Se realizó un estudio con bases técnicas y sociales como fundamento para establecer el **PLAN MAESTRO DE MANEJO DE LA CUENCA DE PÁTZCUARO.** Los Institutos Nacional de Investigaciones Forestales y Agropecuarias y Nacional Indigenista, el Centro Regional de Pesca y el Subcomité de Solidaridad para las Cuencas de Pátzcuaro y Zirahuén, colaboraron en forma interdisciplinaria para reunir información y experiencias que permitan fundamentar el establecimiento de dicho plan.

Con base en la investigación y experimentación de campo, recopilación bibliográfica, estadística y cartográfica, aplicación de Sistemas de Información Geográfica e investigación social, se generó una base de datos, cuya interacción e interpretación indican como resultados más importantes los siguientes:

1. Los sistemas de producción empleados en la cuenca fueron óptimos en un momento dado, pero actualmente no han elevado de forma importante la producción y sí han causado un fuerte deterioro. Se requiere renovar el tipo de tecnologías de producción.
2. La población que asciende a 78,475 habitantes tienen un 24% de población indígena (más de una tercera de parte del total).
3. El modelaje obtenido mediante el SIG muestra opciones para recuperar la cuenca entre 3 y 15 años.
4. La actividad agrícola es la más erosiva en cuanto a producción de azolve y a hectareaje degradado total. El sobre pastoreo es la actividad más erosiva por unidad de superficie.
5. Es indispensable el control del pastoreo y sobrepastoreo en potreros en general y sobre todo en aquellos sujetos a renta de tierras.
6. Es imprescindible controlar la pesca para evitar la extinción de especies.
7. Es urgente apoyar obras de conservación de suelos, reforestación y control de contaminantes en localidades urbanas y rurales.

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INTRODUCCIÓN

El tema de este simposio, no puede ser más oportuno y urgente, es un medio para aportar información útil que ayude a resolver los problemas forestales que se están presentando en todas partes. Nuestra preocupación es muy grande respecto a la situación actual de los recursos naturales de México, que además es un problema común en la mayor parte de los países Latinoamericanos.

Los principios de la producción sostenible son los mismos, pero el grado de complejidad cambia en función de la naturaleza de los problemas. Lograr que la producción forestal sea sostenible es muy diferente en un bosque del Estado de Oregon que en un bosque de los Estados de Jalisco o de Michoacán.

En México las condiciones socioeconómicas y la densidad de población, determinan necesidades apremiantes para los habitantes establecidos en el bosque o en su vecindad. Además de explotar el bosque, se ven obligados a establecer sistemas rudimentarios de explotación agrícola y ganadera para poder subsistir; en muchas ocasiones lo hacen en lugares donde el uso del suelo indica que estos sistemas están fuera de lugar. Con el tiempo los efectos en el ambiente confirman lo anterior.

Los resultados son preocupantes: el grado de erosión y la desaparición de especies en el bosque o lo que fue bosque, alrededor de los núcleos de población humana es intenso, este problema aumenta a medida que se incrementa la población humana, así la selva tropical que alguna vez tuvo la capacidad de cicatrizar las heridas que le producía el sistema de "roza tumba y quema", va perdiendo esta capacidad a medida que aumenta la frecuencia con que se usa. Algo similar ocurre también en el bosque templado.

Desafortunadamente no sólo son la agricultura, la ganadería y el desmonte ilegal, sino también una serie de acciones extractivas como: la venta de tierra orgánica, la captura de animales y la recolección de plantas comestibles o de ornato. Por otro lado, es también nocivo el efecto de la contaminación con desechos orgánicos y químicos derivados de las actividades humanas.

Este contínuo deterioro, no tiene su origen en una actitud perversa de los habitantes; es más bien, una combinación de ignorancia, con la necesidad impostergable de subsistir.

En algunas regiones del país, aparecen situaciones especiales que despiertan cierto interés en la comunidad para la solución de los problemas ecológicos y deciden realizar obras de rehabilitación ambiental y concretamente, la recuperación parcial del bosque original. En estos casos, intervienen programas oficiales y también se da la participación y aplicación de recursos no gubernamentales.

Esto definitivamente es bueno, pero no todo lo bueno que pudiera ser. La falta de coordinación entre instituciones, disminuye la eficiencia de las acciones y por otra parte se carece de un plan maestro, al que las instituciones participantes deben ajustar sus actividades para lograr una meta común en el tiempo programado.

Otro punto importante, está relacionado con la investigación, para resolver problemas ambientales de esta índole: Las instituciones de investigación trabajamos en forma departamental, cada disciplina o especialidad actual independiente de las otras, la integración horizontal es la excepción, no la regla.

La cuenca del Lago de Pátzcuaro en Michoacán, es una cuenca cerrada de casi cien mil hectáreas que ha estado habitada por muchos siglos, fue inclusive sede de culturas pre-hispánicas avanzadas y presenta los problemas siguientes :

1. La erosión presente en diversos grados, es muy alta en algunas partes de la cuenca, debido a los sistemas de producción empleados, lo cual obviamente se refleja en los niveles de sedimentación en el lago.

2. Disminución acelerada de la superficie de bosque original y deterioro del bosque actual.

3. Presencia del proceso de desertificación.

4. Desaparición parcial o inclusive total de plantas y animales nativos.

5. Contaminación del lago por drenajes y otras actividades ribereñas, como son los desechos de curtidurías.

6. Los principales problemas de la cuenca son representativos de muchos lugares de México y de Latinoamérica.

Buscando la solución a estos problemas, el Instituto Nacional de Investigaciones Forestales y Agropecuaria dió los siguientes pasos:

1. Organizó una reunión con la mayor parte de las instituciones gubernamentales y no gubernamentales a quienes se les planteó la necesidad de elaborar un plan maestro de investigación y desarrollo, a fin de programar todas las acciones enfocadas a lograr metas comunes. Esta coordinación haría, sin duda, más eficiente cada uno de los esfuerzos individuales.

2. El INIFAP se comprometió a trabajar en la sistematización de la información disponible, que sería la base para diseñar el plan maestro. Este plan se elaboraría con la participación de todas las instituciones.

3. Ambos puntos fueron aprobados por las instituciones involucradas.

4. Utilizar la cuenca de Pátzcuaro como un modelo nacional y eventualmente internacional, para la aplicación de metodologías, herramientas y estratégias, en la solución de esos problemas.

5. El INIFAP procedió a la formación de un equipo multidisciplinario de 11 especialistas, en el que se encuentran representados los conocimientos más importantes que se usarán íntegradamente, para el análisis y posible solución de los problemas más importantes de la cuenca. En los casos donde INIFAP no tuviera los especialistas se complementaría con personal de las otras instituciones.

6. Asimismo, se recopiló y sistematizó la información disponible y se buscaron herramientas modernas para realizar el trabajo.

BASES TECNICAS (INIFAP)

Uso de Sistemas de Información Geográfica

Usando el Sistema de Información Geográfica ILWIS, se crearon las bases de datos, se digitalizó la cartografía de la zona de estudio (escalas 1:10,000 1:20,000 1:50,000 1:100,000 y 1:200,000), se uniformaron las escalas, se crearon nuevos mapas (uso del suelo, uso agrícola, fauna, etc.) se hicieron operaciones Booleanas con los archivos digitales, se calcularon superficies, se aplicó modelaje matemático a datos espacio-temporales para obtener escenarios futuros, sin y con diversas acciones de conservación, y con todo esto se produjeron impresiones de mapas de interés, tanto en formato vector como raster.

Población

La población total de la región es de 78,455 personas, distribuidas en aproximadamente 100 localidades, el 51% es rural y el 49% es población urbana, del total de la población regional el 24.05% es indígena.

Descripción de la cuenca

La cuenca del Lago de Pátzcuaro se encuentra en la región central del Estado de Michoacán, es el límite oriental de la Sierra Purépecha. Sus coordenadas son de 19° 25' a 19° 50' de latitud norte y de los 101° 25' a 101° 50' de longitud oeste. Esta cuenca ha sido definida con diferentes límites por diversos autores e instituciones, las mayores discrepancias están en los límites occidentales, las diferencias entre autores van de 5,000 a 30,000 ha, por ello para este estudio se utilizó la delimitación hecha por DIGETENAL (1983).

La cuenca es endorréica, mide 93,429 ha, de las cuales el lago ocupa alrededor del 10 porciento. Debido a que la zona forma parte del Eje Neovolcánico Transmexicano, los materiales litológicos son rocas ígneas extrusivas, hay más de 150 aparatos volcánicos formados por la actividad del Cuaternario (Demant, 1976), esto genera un gradiente topográfico abrupto, que en distancias menores de 5 Km pueden tener un desnivel de hasta 1,300 m. La distribución de superficies por cotas altimétricas va de 17,098 ha entre la cota 2,037 a 2,100 msnm, a 13 ha en la franja que supera los 3,300 msnm.

El lago comprende 8,762 ha que es aproximadamente el 10% de la cuenca, la profundidad se ha reducido mucho. Se digitalizaron las batimetrías de 1944 y 1992 y los datos indicaron que el mayor azolvamiento ocurre

en la parte sur. Se identificaron las especies acuáticas y subacuáticas de vegetación, se midieron los parámetros físico-químicos del agua entre 1994 y 1992, en ellos se nota disminuida la visibilidad de 200 a 20 cm. La conductividad ha aumentado de 450 umhos/cm a 800 umhos/cm. El fósforo, el nitrógeno y las clorofilas han ascendido lo cual confirma la autrofía del lago.

La temperatura va de 18 a 20 °C por lo que es un lago tropical polimíctico continuo, hay uniformidad entre las temperaturas del fondo y la superficie, que indican circulación contínua a lo largo del año. El lago es alcalino (pH 8.8 a 9.1) con bicarbonatos y sodio como iones dominantes. La dureza varía de 125 a 187 mg/l y el oxígeno disuelto de 4.0 a 7.5 mg/l.

La pesca incluye 12 especies de importancia y es una actividad productiva para las comunidades, la producción ha disminuído de 2,524 ton/ha a 977 ton/ha. Actualmente se investiga el cultivo controlado de especies endémicas en peligro (Orbe y Acevedo, 1993).

Además del lago, la cuenca incluye parte de los siguientes municipios: Coeneo (2,425 ha), Erongarícuaro (17,081 ha), Huiramba (1,179 ha), Lagunillas (39 ha), Nahuatzen (7,506 ha), Pátzcuaro (27,504 ha),Quiroga (16,622 ha), Salvador Escalante (597 ha), Tingambato (3,841 ha), y Tzintzuntzan (16,635 ha)

Usando el sistema de Köppen, modificado por García, el clima es Cw2(w)eg, esto es templado subhúmedo con lluvias de verano, con marcha de temperatura tipo Ganges, la temperatura media anual es de 18 °C, la precipitación media es de 931 mm.

El drenaje de la cuenca es de tipo radial, con 963 corrientes, que suman alrededor de un mil kilómetros. Como la precipitación va de 900 a 1,400 mm anuales, la cuenca recibe alrededor de 1,000 millones de m^3 de agua, de los cuales el 80% se pierden por evapotranspiración (Barrera, 1986); las constantes morfométricas de la cuenca (Gómez-Tagle, 1988) son: perímetro 136.8 Km, circularidad 1.27 (K=0.283 P/TA), coeficiente de compacidad 1.48 (K=Pc/P), pendiente media 15.94 (Pm=DL/A) y densidad de corrientes 1.21 (DC=Nc/A).

El área está compuesta por suelos de formación reciente, los cual debido a su origen volcánico son ricos en minerales ferromagnesianos, poco estructurados y sumamente frágiles, los más abundantes corresponden a 37,749 ha de Andosoles (40.39%), 17,090 ha de Luvisoles (18.29%), 10,044 ha de Acrisoles (10.75%), 7,084 ha de Litosoles (7.58%), el resto incluye Cambisoles, Vertisoles, Feozem, Planosoles, Gleysoles y Ranker. No hay fases químicas, la fase física más importante es la lítica superficial, que cubre el 15.23%.

Respecto al régimen de propiedad y parcelación de la cuenca, tenemos que 34,134 ha son ejidales, 27,298 ha comunales, 17,877 ha son de propiedad privada y el resto corresponden al lago (propiedad federal) y a propiedad urbana. La propiedad privada está parcelada en 516 fragmentos de dimensiones muy contrastantes.

Los usos del suelo en la cuenca son: agrícola, pecuario, forestal, lacustre y urbano. Los tipos de vegetación en la cuenca son: bosque de pino-encino, bosque de encino-pino, bosque de encino, tular y matorrales secundarios; en este trabajo, se contabilizaron las superficies en tres rangos de cobertura para cada tipo de vegetación. Se tienen identificadas 1,041 especies terrestres y 20 acuáticas.

Como un resultado de las "actividades productivas agropecuarias y forestales", la pérdida del habitat silvestre ha sido intensa. Entre el período 1960 y 1988 la calidad del habitat bueno disminuyó de 22.06% a 2.34%, en cambio las zonas poco aptas, aumentaron de 66.09 a 73.00%.

Los números indican que NO hay un gran aumento en la producción pero SI una fuerte pérdida de recursos naturales.

Al mapear los datos de erosión hídrica de suelos obtenidos durante siete años de medición en 2,700 puntos de la cuenca (Gómez-Tagle, *op. cit.*), se crearon tres rangos de erosión, alta (15 a 98 ton/ha/año con picos de hasta 480), media (de 3 a 25 ton/ha/año) y baja (de 0.5 a 1.5 ton/ha/año); el proceso de erosión afecta el 88% del área en sus diferentes modalidades. La causa principal se encuentra determinada por el uso (agrícola 40.95%, pastoreo 14.2% y forestal 8%).

Ante la necesidad imperante de controlar el proceso erosivo se han construído diversas obras, para este trabajo se mapearon las edificadas entre 1990 y 1992 por la Secretaría de Desarrollo Agropecuario y Forestal del Gobierno del Estado de Michoacán, 1,842 obras en 117 áreas en 1990, 758 presas en 104 zonas en 1991 y 960 obras en 115

zonas en 1992. Al unir el mapa "obras de conservación" con el de "erosión" se pudo constatar que la ubicación de estas construcciones está bien ubicada en las zonas de mayor pérdida de suelos. También se identificaron y priorizaron los sitios para ubicar las presas en los años subsecuentes.

Con la finalidad de mejorar el uso del suelo y para poder sugerir especies y áreas a reforestar, mediante operaciones en cartografía digital (de altitud, suelo, clima, pendiente) se identificaron las zonas potenciales para múltiples especies forestales y cultivadas, entre las primeras destacan el *Pinus pseudostrobus* con 15,508 ha, el *Abies religiosa* con 13,587 ha y el *Pinus michoacana* con 10,084 ha y como parte de las cultivadas están durazno con 8,683 ha y el ciruelo con 4,460 ha. Para todas las especies se identificó el régimen de propiedad y se calcularon los rendimientos probables para facilitar el manejo de los créditos financieros, para las especies forestales se identificó el grado de erosión de cada una de las áreas para diferenciar así, las posibles zonas de plantaciones comerciales, de las de recuperación. En todos los casos, se cuenta con los paquetes de tecnología sugerida para mejorar el rendimiento de las especies.

PLANEACION SOCIAL-COMUNITARIA (INI)

Como una base para el desarrollo de la cuenca, la planeación social-comunitaria sustentada en la amplia participación de la población es un factor decisivo para la búsqueda de un desarrollo social, económico y cultural más justo y equitativo, que a la vez se traduzca en una mejora sustancial de las condiciones de vida y producción de la población indígena y campesina de la región.

Principalmente, son los indígenas de 35 comunidades que se asientan en la región, quienes mantienen vivo el hermoso Lago de Pátzcuaro, en la medida que les significa una forma de vida que ha sido sustento de su cultura desde hace cientos de años; conservando sus profundas raíces en su vida cotidiana y en sus formas de organización para la satisfacción de sus necesidades fundamentales.

Actualmente esta región aún se caracteriza por la pobreza de la mayoría de sus habitantes, por su falta de empleo y la gran migración existente por su deteriorado ecosistema, por el escaso desarrollo agropecuario y forestal, y las deficitarias condiciones de vida y bienestar social comunitario.

La situación actual de los pueblos indígenas de la región lacustre de Pátzcuaro, no solo expresa diferencias culturales que nos enriquecen sino que además evidencía relaciones de profunda desigualdad con el resto de la sociedad.

Históricamente las comunidades indígenas y rurales han implementado múltiples formas de planeación y programación de acciones orientadas al desarrollo de sus pueblos, familias y región en su conjunto; generando procesos organizativos y sociales de acuerdo a las circunstancias presentes en dicho momento. Actualmente se impulsa una mayor participación, de la sociedad en la resolución de los problemas que nos aquejan tanto en esta región y estado, como en el resto de nuestro país.

En este sentido, a partir de 1990 se ha impulsado un proceso de planeación social y comunitaria para el desarrollo integral de las comunidades indígenas y campesinas que conforman la región. Este proceso se caracteriza por la reflexión, análisis sistemático y permanente donde se privilegia la participación consciente y comprometida de la población y el impulso a esquemas organizativos.

Dentro del Plan de Manejo de la cuenca está en desarrollo el **Programa de Desarrollo Regional Indígena "Purhepecha Lacustre"** en éste se llevaron a cabo 233 talleres de análisis, planeación y programación que han permitido ubicar la problemática local, municipal y regional más relevante desde la óptica comunitaria, así como las alternativas de solución que la propia población consideró más adecuadas, contando con este diagnóstico y propuestas de solución se integraron 85 programas comunitarios de acción inmediata, 5 Planes Básicos para el Desarrollo Municipal Integral; actualmente se desarrolla un amplio proceso de planeación y programación participativa, que unificará los esfuerzos institucionales, comunitarios y de la sociedad civil.

Problemática social en la región lacustre

La situación actual es muy compleja, ya que interactuan y confluyen múltiples factores internos y externos, no obstante la variedad y riqueza de

sus recursos naturales y humanos, se caracteriza la región por la pobreza de sus habitantes y la persistencia de grandes rezagos en la satisfacción del bienestar social de la población que la habita. Podemos afirmar sin temor a equivocarnos, que la población indígena es la más pobre de todas; en su gran mayoría las comunidades indígenas carecen o le son insuficientes los servicios públicos básicos (agua potable, energía eléctrica, drenaje) solo las cabeceras municipales cuentan con todos los servicios y aún le son insuficientes.

En el terreno educativo y de atención a la salud podemos señalar que más que la ausencia de este servicio, la problemática se ubica en la deficiente prestación del mismo y la baja calidad y deterioro de los espacios físicos, así como la ausencia de infraestructura de primer nivel y de apoyo.

Se observa con preocupación que los niveles nutricionales de la población, especialmente infantil juvenil son muy bajos, basándose la dieta en maíz, frijol, chile y ocasionalmente carnes, leche y pescado.

Otro grave problema representa para las familias indígenas y campesinas son las condiciones de la vivienda por la baja calidad de sus materiales, alto grado de hacinamiento y ausencia de servicios públicos (agua-drenaje-energía eléctrica).

Gran demanda se presenta en el incremento y mejoramiento de la infraestructura y equipamiento urbano y comunitario, destacándose calles y caminos de acceso, espacios físicos para la cultura, recreación, deporte, infraestructura comercial y de abasto.

Las actividades productivas de la población se caracterizan por sus bajos niveles de producción y productividad, inadecuado y escaso desarrollo tecnológico, la prácticamente inexistente infraestructura de apoyo a los procesos productivos y su casi nula industrialización.

Socialmente relevante resulta el grave problema que representa la falta de empleo remunerado y el bajo nivel de ingresos de la población y la gran migración temporal y definitiva que esto ocasiona; a las limitantes que impone para el desarrollo de la región:

Bases del programa de desarrollo regional indígena

Esta es una propuesta que surge de la voluntad expresa de las comunidades indígenas Purhepechas y rurales que la ubican como una posibilidad de solución a la problemática socioeconómica y cultural que enfrentan en busca de una vida con dignidad y justicia social.

Apartir del análisis de la problemática, se observó que las acciones institucionales, comunitarias y sociales deben abordarse en los siguientes ejes:

- Económico-productivo.
- Bienestar social, salud e infraestructura comunitaria.
- Turismo y recreación.
- Cultura y educación.
- Comercio, abasto y servicios.
- Ecología, medio ambiente.
- Organización y capacitación para el desarrollo.

Económico-productivo. En este eje de acción, agrupamos las principales actividades económicas y productivas de la región: agropecuarias, pesqueras, artesanales, silvícolas, turismo, abasto y comercialización. Al caracterizarse la economía regional como de subsistencia, con bajos niveles de producción, productividad e industrialización, pretendemos desarrollar un conjunto de acciones articuladas entre sí, que resuelvan de fondo la problemática y generen una base económica para el desarrollo de la región.

Binestar social, salud e infraestructura comunitaria. Es el bienestar familiar y social reclamo fundamental de las comunidades, dados los rezagos ancestrales, carencia e incremento constante de la demanda por lograr mejores niveles en la prestación de los servicios públicos básicos. Actualmente los niveles de bienestar social son aún deficitarios. Estando intrínsecamente relacionados constituyen un eje aglutinador de la acción comunitaria e impulsor de la organización comunitaria.

Turismo, Recreación y Deportes. No siendo actividades atendidas como una acción prioritaria, éstas se han generado a partir de la iniciativa privada, beneficiando a un reducido número de personas y familias, sin embargo tienen un gran potencial de desarrollo para las comunidades indígenas dada la riqueza cultural, arquitectónica y escénica con que cuentan. Frente al escaso desarrollo económico-productivo, empleo y

fuentes de ingreso diversificados, las comunidades y organizaciones se han propuesto impulsar el desarrollo de este eje a través de la explotación de la belleza natural, arquitectónica y cultural de la región lacustre.

Cultura y educación. No obstante ser asiento de la etnia y cultura Purhepecha, actualmente enfrentan una paulatina y persistente pérdida de sus valores ancestrales y una fuerte aculturación. Consientes de esta situación, se han propuesto desarrollar un conjunto de acciones que detengan este proceso, así como el impulso a la conservación y acrecentamiento de los valores y cultura comunitaria Purhepecha.

Ecología y medio ambiente. El grave deterioro ambiental, ha significado empobrecimiento y bajos niveles de producción y productividad, y por ende de ingreso y empleo productivo, las comunidades Purhepechas urgen de instrumentar un conjunto de acciones tendientes a revertir esta situación de extrema gravedad bajo la siguientes lineas de acción:

- Agricultura orgánica e intensiva.
- Protección ecológica y ambiental.
- Reforestación productiva y rescate ecológico.

Organización y capacitación para el desarrollo. Entendemos la organización y capacitación para la planeación social del desarrollo, como un proceso social dinámico, con el objetivo común de potenciar sus tradiciones organizativas y sus capacidades de autonomía en la determinación de sus futuros y sus formas de vida y producción. La generación de un desarrollo integral autosostenido de las comunidades, requiere de un fuerte impulso a la participación consciente y comprometida de la población, pero sobre todo organizada y propositiva y con claridad del futuro deseado y los caminos para lograrlo.

Es voluntad expresa de las comunidades indígenas, mantener e incrementar los procesos organizativos autónomos y el apoyo permanente al incremento de sus capacidades y el adiestramiento, y calificación técnica de sus integrantes.

El conjunto de ejes definidos permiten realizar una acción integral sobre la problemática social más relevante y generar las condiciones mínimas para sentar las bases sólidas de un desarrollo integral en beneficio de la población regional.

PROYECCION DE ACCIONES MEDIANTE SISTEMAS GEOGRAFICOS DE INFORMACION

De acuerdo a lo planteado técnica y socialmente con base en el sistema de información geográfica se modelaron tres escenarios tipo, para proyectar el resultado de diferentes tomas de decisión:

Primero.—Condiciones que ocurrirán si no se emplea ninguna medida en 10 años.

- El lago reducirá su superficie a 6,950 ha. La reducción ocurrirá de sur a norte,
- La isla de Jaracuaro se unirá con la isla de Janitzio por el azolve acumulado,
- La pesca disminuirá en un 40%,
- Se perderá un tercio de la capacidad turística,
- El bosque se disminuirá en 3,000 a 5,000 ha, y
- Aumentarán las plagas y enfermedades en un 10%.

Segundo.—Condiciones que ocurrirán al reforestar las áreas recomendadas en la frontera forestal en un período de tres años :

- Se aumentaría la frontera forestal en 3,737 ha,
- Se reforestarían los matorrales que todavía presentan buenas condiciones de suelo,
- Se dejarían de presentar cárcavas y zonas de erosión por canalillos en el 5% de la cuenca,
- Las especies de la fauna asociadas a orillas de bosque incrementarían sus poblaciones, y
- Aumentaría la inflitración hídrica en un 4%.

Tercero.—Condiciones que ocurrirán si se emplean tecnologías avanzadas agropecuario forestales (en 15 años), como: sistemas silvícolas de bajo impacto, agricultura orgánica, manejo de pastizales, plantaciones forestales comerciales, labranza de conservación, construcción de presas y bordos, dragado y restauración de suelos productivos, tratamiento de aguas, colecta de basuras.

- El proceso de erosión se detendrá en un 60%,

- La erosión alta no aumentará en superficie,
- La explotación ganadera tendrá mayores utilidades por menor movimiento de los animales,
- El bosque se repondrá en un término de 12 años, y
- La agricultura producirá granos en un 12% más.

CONCLUSIONES

Las condiciones ecológicas y sociales del área que reflejan los resultados del estudio realizado nos dan de las siguientes conclusiones previas:

1. Es una prioridad inmediata la atención a los grupos indígenas y población de la cuenca, en cuanto a la calidad ambiental, alimentación, salud, empleo y educación.
2. Se requiere implementar soluciones diferentes a la explotación agropecuaria y forestal tradicional, debido a que los potenciales de producción están llegando a su límite con las tecnologías usadas actualmente.
3. Urge desarrollar un tipo de organización comunal para el uso pecuario de los terrenos bajo bases distintas a las usadas hasta el momento, debido a que en estas zonas se encuentran los registros más altos de erosión hídrica por hectárea. El uso de tecnología de manejo de pastizales en ambientes confinados es indispensable.
4. Las prácticas agrícolas requieren de un reenfoque con base en sistemas menos agresivos al suelo disminuyendo la erosión y conservando más la humedad y la biodiversidad natural.
5. Las prácticas forestales deben incluir reforestaciones y plantaciones comerciales en los terrenos ya detectados como de alta productividad mediante la metodología empleada. Todo ello bajo un plan de reforestación por áreas prioritarias. Es inminente también el empleo de una silvicultura que combine métodos regulares e irregulares conservando el habitát silvestre.
6. El ecoturismo es una alternativa viable en el caso de existir posibilidades de inversión.
7. La regulación de la pesca es de importancia vital para mantener la productividad del lago, controlando las épocas, artes de pesca, especies, pesca furtiva y número de pescadores. Es necesario implementar vedas para especies amenazadas y capacitación de los pescadores.
8. Se deben generar esquemas de educación para adultos que incluyan el planteamiento de solucion acordes con las políticas y posibilidades del área en conjunto.
9. El uso de las bases de datos generadas, permitirá adecuar y compatibilizar las necesidades de la población con las posibilidades y potencial de los recursos naturales.

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Cooperación para el manejo sostenible del ecosistema forestal en la región del Lago Tahoe

Steve W. Chilton

Resumen.—La región del Lago Tahoe es un lugar especial. Fue en alguna ocasión, lugar de inalterada belleza. Sin embargo, como otros lugares naturales, su belleza ha sido comprometida. El progreso de la vida moderna ha disminuido los valores únicos que hacen de la Región Tahoe algo extraordinario. Con la siempre creciente presión sobre la región como un recurso para recreación y centro urbano, la preservación de los valores de la Región Tahoe es vitalmente importante e inmensamente dificil. La restauración de esos valores perdidos durante el tiempo parece imposible.

Hasta recientemente, el manejo de los ecosistemas forestales ha sido considerado una prioridad. Durante la fiebre de la plata y la migración de los colonos europeos hacia el oeste en los años 1800's, casi la totalidad de los rodales de región fueron cortados para obtener madera y combustible para las minas Comstock. Actualmente, los bosques de la región están extremadamente enfermos, debido en parte a las matarrasas de esa era y a la dominación del bosque de abeto que se propagó posteriormente, y en parte debido a la altamente exitosa política de supresión de incendios.

La mision para la Tahoe Regional Planning Agency (TRPA) se muestra en la siguiente declaración:

> *La TRPA encabeza los esfuerzos cooperativos para preservar, restaurar e incrementar el inigualable medioambiente natural y humano de la Región del Lago Tahoe.*

Este compromiso comprende muchas metas y retos, incluyendo el establecimiento de asociaciones para el manejo sostenible de ecosistemas forestales. En octubre de 1992, la TRPA estableció el Grupo de Concenso para el bosque sano, una asociacion pública entre ciudadanos interesados, y especialistas en recursos naturales de agencias privadas y públicas, quienes están consientes que una transición acelerada y segura del actual bosque enfermo a uno sano es compleja, y requiere la visión y compromiso de todos los interesados. Son tareas primodiales del grupo la evaluación de la dirección del manejo forestal en la región y proporcionar asistencia al publico en general y al grupo que toma las decisiones sobre la dinámica actual y a largo plazo del ecosistema forestal, considerando al Ecosistema Forestal de la Región del Lago Tahoe como un todo. El grupo ha definido las condiciones futuras deseables del Ecosistema Forestal de la Región del Lago Tahoe, principalmente la restauración de su condición hasta antes de la llegada de los colonizadores europeos-americanos en la mitad de los 1800's.

Las "definición de las condiciones pre-europeas", están definidas en terminos de los tipos generales de vegetación forestal que predominaron en diferentes localidades a través de la región. Las descripciones sirven como metas generales para los manejadores en su esfuerzo por reestablecer un bosque sano en la región del Lago Tahoe y representan un mosaico de situaciones que abarcan un rango de características que ocurren a través de la variación del tiempo y paisaje. Las metas incluyen un retorno gradual a las proporciones de clases de edad, incluyendo rodales en los últimos estados sucesionales (viejo crecimiento) que se aproximan a los niveles de densidad previos a los aprovechamientos de Comstock. Este objetivo incluye el reconocimiento de las necesidades de retener y promover rodales que muestren, o que puedan fácilmente alcanzar, características de los últimos estados sucesionales (grandes, con muchas ramas, copa abundante o árboles muy altos).

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MENSAJE DE CLAUSURA

Mensaje del clausura

Ing. Víctor Sosa Cedillo[1]

En nombre del Dr. Manuel Mondragón y Kalb, Subsecretario Forestal y de Fauna Silvestre, les transmito sus saludos afectuosos y su felicitación por el éxito alcanzado en este importante simposio.

La Subsecretaría Forestal y de Fauna Silvestre agradece de manera especial el apoyo recibido por parte del Gobierno del Estado de Jalisco, para celebrar el evento en esta hermosa ciudad de Guadalajara.

Reciban también todos los ponentes, participantes y organizadores de este Simposio, el reconocimiento de la Subsecretaría, por su gran entusiasmo para acudir a este evento a aportar sus conocimientos y apoyo, sobre el importante tema del manejo sostenible de los ecosistemas forestales, que es hoy en día, quizá el aspecto más importante que se debate en el ambito mundial forestal.

Por mi conducto la Subsecretaría Forestal desea resaltar que este V Simposio se realizó en el marco de la cooperación bilateral existente entre México y Estados Unidos en materia forestal, que cada día cobra una mayor importancia para el desarrollo de una silvicultura sostenible en norte américa.

Con apoyo en el Memorandum de Entendimiento y la carta de intención que existe entre la Secretaría de Agricultura y Recursos Hidráulicos y el Departamento de Agricultura de los Estados Unidos, se tienen 14 grupos permanentes de estudio, que desarrollan 27 proyectos en diversos aspectos técnicos y científicos relacionados con el manejo sostenible de los recursos forestales, la protección y conservación de los mismos, y que incluyen también acciones en beneficio de la flora y fauna silvestre, como es el caso de las especies migratorias, fundamentalmente en lo relacionado con la mariposa monarca y las aves de diferentes especies.

México y Estados Unidos han establecido el compromiso de lograr una silvicultura sostenible en el mediano y largo plazo. También hay coincidencia en que el manejo del recurso forestal debe transformarse en un manejo integral de los ecosistemas forestales, que permita asegurar que este importante recurso genere los bienes y servicios que requiere la sociedad actual y que habrá de demandar la población en el futuro.

[1]*Director General de Protección Forestal, Subsecretaria Forestal y de Fauna Silvestre, SARH.*

Esta reunión también contribuyó al cumplimiento de los acuerdos en materia forestal derivados de la Conferencia de las Naciones Unidas para el medio ambiente y desarrollo, que se efectuó en Rio de Janeiro en 1992; y de los "principios forestales" que fueron definidos en dicha cumbre.

Nuestro país ha estado trabajando en el cumplimiento de los acuerdos de Rio de Janeiro.

Las principales actividades realizadas en México en materia forestal incluyen la conclusión del inventario forestal períodico, en escala 1:250 mil, recientemente entregado al C. Presidente de la Républica; la disminución de la desforestación de 370,000 hectáreas por año a 242,000 hectáreas en 1993; el incremento de la reforestación anual de 45,000 hectáreas anuales a 110,000 hectáreas el año pasado, y que en este año con apoyo del programa de solidaridad nacional, permitirá establecer un nuevo record nacional con la plantación de más de 150 millones de árboles; el desarrollo y aplicación de métodos para el manejo sostenible de bosques y selvas; la promulgación de una nueva ley forestal en 1992, para desregular el sector, impulsar el manejo forestal sostenible e integrar un Consejo Técnico Consultivo Nacional Forestal y los correspondientes comités a nivel Estatal.

Conjuntamente con Canada, México y Estados Unidos están haciendo esfuerzos para establecer áreas demostrativas de manejo sostenible de los bosques y de las selvas a través de proyectos como los "bosques hermanos" y los "bosques modelo", que permitirán extender estas experiencias, no sólo a diversas zonas de México, sino a otras regiones del mundo.

El análisis de los diversos temas que se efectuaron en esta reunión y las valiosas conclusiones que escuchamos hace unos momentos, serán fundamentales para lograr en un futuro cercano una silvicultura sostenible en la región de norte américa.

Por todo lo anterior, la Subsecretaría Forestal y en especial su titular el Dr. Manuel Mondragón y Kalb, apoyaron desde un principio la iniciativa de realizar este simposio, que sin duda constituirá un punto de referencia fundamental en la tarea de lograr la permanencia de los bosques, en beneficio de la población actual y la de los años venideros.

Muchas Gracias.

CARTELES

Aprovechamiento sostenible de *Yucca schidigera* como una necesidad socioeconomica en Baja California

Jorge I. Sepúlveda Betancourt[1]

Yucca schidigera Roezl. es una especie endémica de los desiertos del suroeste de Norteamérica. Se distribuye en los Estados de Nevada, Arizona y Baja California. En México es aprovechada desde 1975. El jugo extraído de sus tallos es fuente de saponinas. El volumen de extracción es de 5,000 toneladas anuales en las que participan 16 comunidades rurales beneficiando a 1,500 productores. La creciente demanda del mercado, la fragilidad del habitat en donde se desarrolla y el escaso conocimiento que se tiene sobre ésta planta ha creado expectación respecto a su permanencia. A partir de 1990 el Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), viene desarrollando investigaciones con el objeto de generar conocimiento científico y tecnológico, el cual permita el aprovechamiento sostenible de éste recurso forestal.

La estrategia de investigación en poblaciones naturales incluye inventario, estudios autoecológicos, dasométricos y validación de técnicas silvícolas. En el área de domesticación y cultivo se incluyen trabajos de mejoramiento, métodos de producción de planta y técnicas de plantación.

Los resultados obtenidos en los estudios de autoecología, muestran que *Yucca schidigera* se localiza en Baja California en una franja de 350 kilómetros, la cual inicia en la frontera México-Estados Unidos y termina en el paralelo 30° de latitud norte. Este límite está asociado a altas temperaturas (36° C), bajas precipitaciones (120 mm) y suelos de textura arcillosa. Las poblaciones más productivas se desarrollan en bosques de piñón-junípero, chaparral y matorral desértico. La densidad de planta varía en un rango de 44 a 283 colonias/ha que contienen entre 500 a 2,800 fustes/ha. Los rangos de altura en plantas adultas oscilan entre 2.8 a 4.1 metros y diámetros de 7 a 36 centímetros. La estructura poblacional registra un alto porcentaje de individuos de la clase de altura entre los 0 y 100 cm. Experiencias de aprovechamientos anteriores, muestran que intensidades de corte entre el 10 y el 25% producen un efecto de rejuvenecimiento de la población y estimula el crecimiento de las plantas. Las evaluaciones de la tasa de crecimiento realizadas en sitios permanentes de observación, arrojaron una relación lineal entre la velocidad de crecimiento y la altura de la planta con un mínimo de 1 cm/año en las clases de altura de 0 a 50 centímetros y un máximo de 6 cm/año en las clases de 2.5 a 3 metros.

En el área de domesticación y cultivo, *Yucca schididigera* mostró un alto porcentaje de germinación bajo condiciones de vivero (85-90%) con un crecimiento de 15 cm/año en los primeros dos años. Dentro de la evaluación de los métodos de plantación por medio de rosetas hijuelos y semillas a la fecha, el método más exitoso, ha sido el de hijuelo con sobrevivencias hasta de un 90%. Dentro de las principales causas de mortandad registradas en las plantaciones experimentales destacaron la sequía, seguida del ataque de lagomorfos. La generación de tecnología para el establecimiento de plantaciones, permitirá satisfacer la demanda de la industria y paralelamente disminuir la presión ejercida sobre las poblaciones naturales.

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Algunos impactos del arrime de trocería con motogrúa

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Este trabajo se deriva del estudio titulado "Integración de Operaciones de Abastecimiento de Productos Forestales", y en él colaboraron con el INIFAP, la empresa "Forestal Líder" y la Unidad de Conservación y Desarrollo Forestal (UCODEFO) N° 8 "Regocijo", del Estado de Durango.

E1 objetivo de este estudio fue determinar el daño que causa el arrime de trocería al arbolado residual y proponer acciones para disminuirlo.

Se determinaron las condiciones generales del área de corta y del arbolado aprovechable y se describió la manera como se realiza actualmente el arrime de productos maderables con motogrúa.

Se estudiaron siete lugares donde se instaló la motogrúa, analizando la longitud de los carriles de arrime que se formaron, la cantidad de trozas, el volumen de madera extraída y los daños causados al arbolado residual, tanto al de dimensiones comerciales (diámetro normal superior a 10 cm), como al arbolado no comercial.

Se determinó que en promedio se extrajeron 18.174 m^3 en rollo distribuidos en 22 piezas de trocería, en cada instalación analizada.

Del volumen comercial que se queda en pie en los carriles de arrime, se observó que el equivalente a un 4.5% del volumen extraído sufre daños tan drásticos que sería preferible haberlo "marcado" y aprovechado en el mismo ciclo de corta. Esto puede representar un volumen de 10 m^3 en rollo por semana, dañados drásticamente por cada motogrúa dedicada al arrime de trocería.

En cuanto al arbolado no comercial (con diámetro normal menor a 10 cm), se observó que en promedio el 80.7% de los árboles con estas características que se quedan en pie en los carriles de arrime, sufrió daños drásticos (que les causan la muerte). Esto representa que se dañan 2.14 árboles pequeños por cada metro cúbico de madera extraída.

Es recomendable trazar carriles de arrime oportunamente, para que se marque el derribo y aprovechamiento el arbolado residual que ahí se encuentre, considerándolo como una parte del volumen anual autorizado con base en el estudio forestal respectivo.

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Manejo de ecosystemas forestales en el ejido "El Largo", Chihuahua

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Las contradicciones de una sociedad en desarrollo y el incremento de la población, representan dos fenómenos que a la par demandan una mayor y mejor producción de bienes y servicios derivados del bosque; por ello es preciso encontrar respuestas viables que sustenten de una manera responsable el uso y el manejo de estos ecosistemas. Con la integración de acciones relevantes, se pretende por principio establecer el balance entre las necesidades sociales y la funcionalidad del ecosistema, bajo la premisa del desarrollo sostenible, que asegure que los bienes y servicios sean aprovechados por la sociedad en forma permanente y continua.

En este marco conceptual, para los manejadores de bosques ha sido un reto encontrar nuevos sistemas de manejo, en cuyos planteamientos se contemple además de la diversificación de productos y servicios, sostener la biodiversidad, la sanidad, el vigor y la productividad de los ecosistemas forestales.

En los bosques que vegetan en el ejido "El Largo", Estado de Chihuahua, se ha iniciado el manejo de sus recursos naturales, bajo el esquema de **Manejo de Ecosistemas**, cuyo contenido parte de la premisa de obtener un futuro deseable a partir de un presente conocido, representado por las condiciones ambientales, así como el entorno de las necesidades socioeconómicas de los dueños de ese recurso, sobre una escala múltiple, pero siempre enfatizando la permanencia de un balance entre la sostenibilidad y el uso científico y responsable del ecosistema forestal.

Esta nueva filosofía, está implementándose bajo un proyecto de participación entre los gobiernos de México y Estados Unidos de América, con un pensamiento en común: Definir las alternativas más viables desde el punto de vista social, económico y ambiental, que garanticen el uso integrado de los ecosistemas forestales, bajo el concepto de sostenibilidad.

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Programa computacional para la evaluación de rodales naturales de candelilla

Federico E. de la Garza[1] y Melchor García Valdéz[1]

INTRODUCCION

En el desierto de Chihuahua, alrededor de 20,000 campesinos tienen como principal actividad la extracción de cera de candelilla (*Euphorbia antisyphillitica*), siendo en algunas ocasiones su única fuente de ingresos.

Con 1a finalidad de preservar los recursos forestales de México, se cuentan con reglamentos para el otorgamiento de los permisos de aprovechamiento, condicionándolos a 1a realización previa de Estudios Técnicos Justificativos que permitan conocer las existencias del recurso. Normalmente estos estudios son complejos, lentos y costosos, requiriéndose de alternativas más eficientes de evaluación.

OBJETIVO

Reducir significativamente mediante el desarrollo de un sistema de cómputo, el trabajo y tiempo necesarios para efectuar la evaluación del recurso candelilla.

METODOLOGIA

En la elaboración del sistema de cómputo, se utilizó el lenguaje de programación **Basic**, desarrollándose un programa de uso sencillo y entendible, lográndose guiar al usuario por medio de subrutinas a través de pantallas, para la captura de los datos de alturas y diámetros de plantas previamente muestreadas en campo, con los que el sistema genera una base de datos que permite la creación de archivos específicos por predio o rodal muestreado, dándose a la vez la oportunidad de revisar y/o modificar dichos archivos.

RESULTADOS Y CONCLUSIONES

Una vez capturados y revisados los datos, el sistema calcula, mediante tablas de producción, las existencias de hierba de candelilla en cada sitio de muestreo, a la vez que analiza estadísticamente los resultados obtenidos. Finalmente, se muestra en pantalla los resultados de varianza entre sitios y el número de sitios de muestreo requeridos para ser estadísticamente confiable la información, asi como las estimaciones de existencias de candelilla en el rodal con respecto a hierba verde y Kilogramos de cerote por hectárea.

El sistema cuenta además, con una sección de ayuda, donde se define la metodología para la rodalización y el muestreo en campo, así como el método de aprovechamiento adecuado para lograr la sostenibilidad de las poblaciones de candelilla. Permitiendo este sistema de computo eficientar el trabajo de escritorio de los técnicos responsables de la evaluación del recurso, dado que el tiempo de evaluación de los rodales en su fase de oficina se reduce a una vigésima parte de la actual, a la vez que las posibilidades de error se reducen considerablemente, permitiendo la evaluación del recurso bajo un método no destructivo, y promoviendo el aprovechamiento adecuado para su conservación.

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Establecimiento de zacate buffel y *Leucaena* en áreas degradadas

Lorenzo J. Maldonado Aguirre[1]

INTRODUCCIÓN.— La vegetación dominante en el noreste de México es el matorral espinoso, formado por arbustos tendientes hacia el xeromorfismo; esta comunidad vegetal ha sido por más de 350 años fuente de leña combustible, carbón, estantes, forraje para el ganado y refugio de la fauna silvestre: estos aprovechamientos, conjuntamente con el sobrepastoreo y desmontes mal planeados, han perjudicado el régimen de aguas en las laderas aumentando las escorrentías. La eliminación de árboles y arbustos, ha acelerado en varios lugares la erosión eólica, sus suelos no estruturados y de textura ligera resultan afectados, volviéndose notablemente improductivos.

OBJETIVOS.— La presente investigación se estableció con el propósito de definir en términos de producción de forraje y la conservación de la biodiversidad, la relación óptima entre el área de escurrimiento de agua de lluvia y el área de desmonte para la siembra de zacate buffel *Cenchrus ciliaris* L. y la plantación de *Leucaena leucocephalla* [Lam] de Wit.

METODOLOGÍA.— La investigación se realizó en el rancho ganadero "San Lorenzo" localizado en el Municipio de General Terán, Nuevo León, México, seleccionando un terreno con el 5.8% de pendiente; el clima es el seco semicálido con lluvias en verano, la precipitación pluvial es de 583 mm al año y la temperatura media de 22.4°C. Los suelos son someros, de textura franco arenosa, estructura granular, con presencia de pedregosidad y un pH de 7.2. La vegetación es el matorral alto espinoso. En marzo de 1991, se levantaron bordos con un intervalo vertical de 1.17 m derivado de la fórmula I.V.-% pendiente + 2 x 0-15; éstos tienen la función de captar y distribuir los escurrimientos pluviales. A ambos lados de los bordes y a una distancia de un metro se plantó *Leucaena* con miras a protegerlos, fijar nitrógeno y producir forraje. Los tratamientos fueron: relación área-siembra área tributaria de escurrimientos de 100-0, 75-25, 50-50, 25-75, 0-100% (testigo) y testigo absoluto (vegetación nativa), se sembró zacate buffel en el área desmontada. El diseño fue de bloques al azar con cuatro repeticiones; la unidad experimental está dada por los bordos con una longitud de 12.5 m.

RESULTADOS Y DISCUSIÓN.— A 1,041 días de establecida la pradera, se tiene el 69% de sobrevivencia en *Leucaena*. Respecto a los tratamientos de zacate buffel, se evaluaron a través de ocho cortes, los cuales se efecturaron al 60% con relación a la altura del zacate y con un error de muestreo de 8.25% (Snedecor, 1962); inmediatamente después de cada corte, se introdujo ganado bovino para uniformar el factor uso en cada tratamiento. Los resultados obtenidos acumulando los ocho cortes que son: 1) Relación 100% siembra-0% escurrimiento: 39,458 Kg ha^{-1} referido a materia seca utilizable; 2) Relación 75-25%: 39,341 Kg ha^{-1}; 3) Relación 50-50%: 38,480 Kg ha^{-1}; 4) Relación 25-75%: 39,527 Kg ha^{-1}; 5) Relación 0-100% (testigo) 4,221 Kg ha^{-1} y 6) Testigo absoluto 941 Kg ha^{-1}; estas dos últimas, referidos a materia seca de zacates nativos. Con base a lo anterior y con el análisis de varianza y de separación de medias, los tratamientos son iguales entre sí pero definitivamente superiores a los testigos.

CONCLUSIONES.— Los resultados de la presente investigación indican que en ese tipo de regiones es posible aumentar la producción de materia seca utilizable de 941 kg ha^{-1} en el testigo absoluto hasta 39,527 kg ha^{-1} en la relación 25% de siembra -75% de escurrimiento, lo que significa un incremento de 4,100%, además de conservar la biodiversidad y proteger el suelo contra los procesos erosivos.

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Proyecto selva Baja Caducifolia, un estudio enfocado hacia la sostenibilidad

José Concepción Boyas Delgado[1], María Mariela Linares Avila[2] y Juan M. Javelly Gurría[2]

La selva baja caducifolia (SBC) tiene amplia distribución en México, ya que cubre aproximadamente 16 millones de hectáreas del territorio nacional. En la República Mexicana, este ecosistema tiene gran importancia ecológica, económica, antropológica, etnobotánica y ecoturística; en contraste, éste tipo de vegetación ha sido de los más impactados por severos cambios de uso del suelo hacia fines agropecuarios y por asentamientos humanos, debido a que no se han establecido las mejores estrategias para su aprovechamiento racional y su conservación.

Tomando en cuenta esta problemática, el Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP) ha desarrollado un Proyecto sobre selvas bajas caducifolias en el sur de México, con el propósito de encontrar las mejores alternativas para el aprovechamiento sostenible de este recurso forestal. Este Proyecto contempla tres etapas básicas de investigación: l) Regionalización ecológica de la SBC a partir del modelo de unidades ecológicas; 2) Determinación de la productividad forestal de cada unidad ecológica, a partir de la vegetación arbórea, fauna silvestre e insectos; y 3) Definición de alternativas sostenibles de la SBC en cada unidad ecológica.

Para la definición de las unidades ecológicas de la SBC, se utilizó material cartográfico del ambiente biofísico, el cual fue analizado a través de la técnica de sobreposición de mapas, complementado con un análisis de correlación cartográfica. La productividad forestal arbórea fue estimada a partir de sitios temporales de dimensiones fijas de 0.1 hectárea, en los cuales se evaluaron las características dasométricas de todas las especies arbóreas mayores de 5 centímetros de diámetro normal; la fauna silvestre se determinó mediante transectos lineales de 1.5 Kilómetros en los cuales se hicieron censos de las especies de fauna presentes, tanto por contacto visual como por evidencias indirectas; los transectos se establecieron siguiendo un gradiente altitudinal dentro de la unidad ecológica de la SBC; para el registro de insectos se utilizaron distintas técnicas de trampeo y colecta de este grupo taxonómico en las mismas unidades ecológicas estudiadas, tanto para la vegetación como para la fauna silvestre.

De las tres etapas de investigación, se tienen resultados finales de las dos primeras y se encuentra en fase de estudio la tercera de ellas. En relación con la regionalización ecológica de la SBC, se definieron las unidades ecológicas de mayor representatividad con este ecosistema, las cuales han sido caracterizadas desde un punto de vista físico y biótico; en relación con la vegetación, se determinó la composición y estructura arbórea, volumen y calidad maderable por especie, tablas de volumen para las especies más abundantes, regeneración arbórea y usos tradicionales de la mayoría de las especies arbóreas. En cuanto a fauna silvestre se obtuvieron estimaciones de densidad poblacional y hábitos alimenticios para las especies más representativas, así como los usos tradicionales para la mayoría de las especies faunísticas. En relación con insectos, se obtuvo un catálogo taxonómico y se agruparon en insectos útiles y perjudiciales.

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Propagación de cuatro especies latifoliadas de la selva Baja Caducifolia del Estado de Morelos

Martha Alicia Cervantes Sánchez[1]

El presente trabajo incluye la integración de varias actividades de investigación enfocadas a definir la metodología para propagar cuatro especies prioritarias de uso múltiple de la Selva Baja Caducifolia (SBC), del Estado de Morelos: palo dulce (*Eysenhardtia polistachya*), guamúchil (*Pithecellobium dulce*); tehuistle (*Acacia bilimekii*) y cuahulote (*Cuazama ulmifolia*). Estas especies fueron seleccionadas por la amplia relación que guardan con las comunidades humanas del clima trópico seco de este Estado, las cuales son abastecedoras principalmente de combustibles, postes para cercos y construcción, presentando a su vez una diversidad de usos relacionados con actividades de trabajo medicinal y comestible.

La metodología comprende la definición de épocas de recolección de semilla, mediante estudios fenológicos; caracterización de semilla; determinación del tipo de sustrato para siembra y tiempo de producción en vivero.

Los resultados muestran que los períodos más recomendables para la recolección de semilla son: noviembre para el palo dulce; abril para el guamúchil y tehuistle y enerofebrero para el cuahulote.

La calidad de semilla y comportamiento de la germinación varian de acuerdo a la especie y procedencia, denotándose la necesidad de aplicar algún tratamiento a la semilla.

El tiempo de producción en vivero varía según la especie: guamúchil dos a tres meses; palo dulce y tehuistle cinco meses y, cuahulote seis meses.

La información técnica recopilada en este trabajo es la base para elaborar guias técnicas de producción de plantas, para la obtención de planta de buena calidad en el menor tiempo posible.

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Participación de la comunidad de Ixtlán, Oaxaca, en la protección y aprovechamiento de los recursos forestales

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El presente estudio tiene como objetivo principal, dar a conocer la coordinación y vinculación existente entre el Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP) y la Unidad Comunal Forestal, Agropecuaria y de Servicios (UCFAS) de Ixtlán de Juárez, Estado de Oaxaca, México. La UCFAS se encuentra integrada por 400 comuneros que se benefician directamente del aprovechamiento de sus bosques. La organización se encuentra constituida por una coordinación general que se apoya en los Servicios Técnicos Forestales para el aprovechamiento, abastecimiento, transformación y comercialización derivados del cultivo del bosque.

La UCFAS para el desarrollo de sus actividades, posee una superficie total de 19,500 hectáreas de las cuales el 61.5% está cubierto por bosque templado y del total de la superficie, el 45% es susceptible de aprovechamiento comercial. Dispone además, de un total de 2,300 hectáreas segregadas de aprovechamiento con fines de protección y fomento. La posibilidad de aprovechamiento anual está dado por 71,000 metros cúbicos, de los cuales el 72% corresponde a pino y el volumen restante a encino; sin embargo, actualmente sólo se aprovecha el 57% de dicha pasibilidad.

Con la finalidad de apoyar hacia un objetivo de manejo con rendimiento óptimo, continuo y sostenido, sin menoscabo de sus recursos forestales, el INIFAP (en su Centro de Investigación Regional Pacífico Sur) desde 1973 a la fecha, participa en la generación de información y tecnología en los siguientes aspectos:

- Tablas de producción para *Pinus patula*.
- Determinación del potencial productivo de especies forestales.
- Tratamientos al suelo para la repoblación de *Pinus patula*.
- Aplicación y evaluación de aclareos en bosque de *Pinus patula*.
- Validación de tablas de volúmenes.
- Evaluación de impactos al suelo por la actividad forestal.
- Evaluación genética de rodales, áreas y árboles semilleros de las especies de pino presentes.

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Contenido de metales pesados en suelos forestales

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Debido al alto grado de deterioro que se observa en los ecosistemas forestales de algunas regiones de México, por diferentes factores como: Transporte automotriz, extracción de agua, plagas, enfermedades y contaminación atmosférica, se planteó la necesidad de realizar estudios relacionados con la contaminación de los suelos por metales pesados.

Los objetivos fueron conocer los contenidos de algunos metales pesados tóxicos en los suelos y relacionarlos con las propiedades químicas del mismo, así como con la vegetación arbórea existente en las áreas de estudio.

El trabajo se llevó a cabo en campo y laboratorio; los muestreos se realizaron en 1992, en la localidad de San Juan Tetla, Estado de Puebla, con una vegetación natural de *Pinus montezumae*, Desierto de los Leones, D.F. (Cementerio) con una plantación joven de *Pinus montezumae*, *P. ayacahuite*, *P. patula* y *P. radiata*; San Rafael con una plantación de *Pinus ayacahuite*.

La selección de sitios se hizo con la ayuda de mapas de suelos y vegetación elaborados por el Instituto Nacional de Estadística, Geografía e Informática. Las muestras de suelo se tomaron a una profundidad de 0 a 30 cm lineales entre sí. Las propiedades químicas (pH, Materia Orgánica, Nitrógeno Total, Capacidad de lntercambio Catiónico, P, Ca, Mg, Na, y K) fueron analizadas con las metodologías propuestas por Lim y Jackson (1982); y la extracción de metales pesados (Cr, Zn, Fe, Cu, Mn, Pb y Al) con DTPA (ácido dietilen treiamino pentacético)y se cuantificaron en el Expectrofotómetro de Absorción Atómica.

El contenido de metales pesados en San Juan Tetla es menor, en comparación con las otras dos áreas estudiadas. En el Desierto de los Leones y San Rafael se encontraron valores similares a excepción del Pb, Fe y Al, siendo mayor el contenido de Pb (70 p.p.m.) en el primero, y Fe (43.7 p.p.m.) y Al (156 p.p.m.) en el segundo. Las propiedades químicas del suelo presentan variaciones en los tres lugares, principalmente en M.O., N.T., C.I.C., Ca, Mg y K, las cuales intervienen en los ciclos de nutrientes. Existe la posibilidad de que el tipo de vegetación presente (Bosque de Pinos) y las propiedades del suelo jueguen un papel importante ya que, en donde el contenido de M.O.y N.T. es menor, se observa que las concentraciones de Al y Fe son mayores debido posiblemente al pH del suelo. La distancia de la fuente de origen de los contaminantes, así como la localización y exposición de los sitios influyen en la concentración de metales pesados presentes en las áreas de estudio.

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Distribución ecosistémica de las plantas comestibles de Xochitlán y Zapotitlán, Puebla, México

Genoveva Villalobos Contreras[1] y Miguel Angel Martínez Alfaro[2]

Los Nahvas de Xochitlán de Vicente Suárez y los Totonacas de Zapotitlán de Méndez en la Sierra Norte de Puebla, consumen 210 plantas comestibles, que se encuentran distribuidas en tres ecosistemas naturales y trece habitat modificados, de los cuales el bosque subcaducifolio se caracteriza por tener un mayor número de plantas comestibles y también en los huertos familiares. El aporte de nutrimentos es mayor en los huertos familiares, pues destacan las especies como el frijol y el maíz que tienen valores proteínicos y energéticos.

En los ecosistemas naturales y habitat modificados se reportan 72 especies en el estrato arbóreo, 18 en el arbustivo y 120 en el herbáceo. En habitat poco diversificados, el número de especies comestibles es menor que en los cultivos mixtos y a su vez, es menor que en los ecosistemas naturales.

Las especies que están distribuidas en un mayor número de habitat son: *Xanthosoma* spp., *Begonia* spp., *Rhipsalis baccifera, Acrocomia mexicana, Peperomia* spp., *Passiflora* spp., *Pouteria sapota, Smilax* spp. Estas especies siguen aprovechándose sin ser extraidas. Principalmente aportan vitaminas y carbohidratos.

Las especies introducidas que se adaptan a las condiciones climatológicas, edáficas, etc., son: *Ruta chalepensis* y *Coriandrum sativum*, entre otras. Principalmente son condimenticias, aportan poca cantidad de vitaminas.

Las especies más utilizadas que no se adaptan al clima y que no se encontraron en habitat alguno son: *Capsicum annuum* var. *grossum, Sesamum indicum* y *Petroselinum crispum.*

Las especies que se encuentran restringidas a sus habitat naturales y que no permiten su crecimiento en otras áreas debido a que son consumidas en tiempos de escasez, son: *Ceratozamia mexicana* y *Cyathea sp.*

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Cooperación social del Grupo Cívico Forestal de la U.A.A.A.N., las actividades de protección, conservación y fomento forestal

Jorge David Flores Flores[1]

El Grupo Cívico Forestal, es una corporación de profesores y alumnos de la Universidad Autónoma Agraria Antonio Narro (U.A.A.A.N.), debidamente organizados, capacitados, equipados y registrados oficialmente ante las autoridades de la Delegación de la Secretaría de Agricultura y Recursos Hidráulicos en el Estado de Coahuila, para participar en forma integrada en una serie de trabajos tendientes a la protección, conservación, fomento y cultura de las áreas arboladas y sus recursos asociados, en beneficio de áreas rurales, urbanas y conurbadas de los municipios ubicados al sur del Estado de Coahuila.

Nuestra participación es totalmente altruista y voluntaria, no recibimos ningún pago de honorarios por nuestros servicios; nos mantenemos con el apoyo económico de la propia Universidad, con eventos y aportaciones de los miembros del Grupo Cívico Forestal. Este principio es fundamental para poder fomentar la concientización forestal y que la participación de sus miembros no sea influenciada por ningún interés económico. A los alumnos que así lo deseen, se les considera esta participación para cubrir el requisito del Servicio Social para graduarse.

Los resultados más destacados de los últimos tres años son los siguientes:

Actividades de reforestación:

Zona Rural—Se reforestaron 150 hectáreas.
Zona Urbana—Se realizaron actividades de arborización en 20 escuelas del Municipio de Saltillo, en 5 de Ramos Arizpe y en 3 de Arteaga, en el Estado de Coahuila.
Zona Conurbada—Se reforestaron 20 colonias, 5 parques y 2 boulevares.

Actividades de educación forestal:

Se atendieron a 3,000 niños de 30 diferentes escuelas.

Prevención y combate de incendios forestales:

Se ofrecieron cinco cursos donde se capacitaron a 180 personas.
Se participó en la campaña contra incendios con 30 integrantes del Grupo Cívico Forestal.

Labores de limpieza:

Se hicieron labores de limpieza de las carreteras que convergen a la Universidad, recolectándose más de 10 toneladas de basura.

Podas y Jardinería:

Se podaron cinco hectáreas de la reforestación Zapalinamé y 50 árboles en escuelas de la Ciudad de Saltillo.

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Estructura y relación del sotobosque con plantaciones forestales y factores físicos de la zona oriente de la cuenca de México

María Lucila Gutiérrez Rodríguez[1], José Luis Oropeza Mota[2], Carlos Rodríguez Franco[3], Alejandro Velázquez Martínez[4] y Armando Gómez Guerrero[5]

La eliminación del bosque en la zona oriente de la Cuenca de México tuvo como consecuencia su degradación. Ante esto, desde 1970 se han realizado prácticas de conservación de suelo y plantaciones forestales en áreas severamente erosionadas para protección, restauración y mejoramiento de la capacidad productiva de la zona. Debajo de este dosel artificial se establecen de manera natural comunidades vegetales (sotobosque), que contribuye a los mismos objetivos. La importancia de conocer la estructura, composición y patrón espacial del sotobosque radica en que frecuentemente se utilizan como indicadores del efecto en el ambiente del manejo y la reforestación. Por lo que, los objetivos de este trabajo son conocer la estructura y relación del sotobosque con plantaciones forestales y factores físicos en que se desarrolla.

De 105 sitios muestreados al azar en las zonas reforestadas, se obtuvieron variables fisiográficas, dasométricas y del sotobosque. Para cada especie herbácea se determinó su frecuencia, abundancia y valor de importancia por sitio y plantación forestal. Se hizo la comparación de medias para las variables dasométricas y del sotobosque por práctica de conservación. Se realizó una correlación entre la cobertura herbácea (COB) y las variables fisiográficas y dasométricas por especie forestal. Después, cada tipo de variable se sometió a ordenación mediante componentes principales; luego, a clasificación por la técnica aglomerativa: Distancia Euclideana Ponderada. Finalmente, se exploró el comportamiento de COB en relación a los gradientes ambientales encontrados.

Los resultados indican que *Pennisetum clandesfenum* Hoscht., supera en relevancia ecológica al resto de las herbáceas. En general, no se encontraron diferencias significativas para las variables del sotobosque y dasométricas entre las diferentes prácticas de conservación. El análisis de correlación sólo mostró coeficientes notables en algunas plantaciones; por ejemplo, en el caso de *Cupressus lindleyii* Kloscht., la COB se asoció a la profundidad de suelo (PS) con un coeficiente de 0.65 y -0.54 con la densidad de plantación. Para *Casuarina equisetifolia* L., la COB se correlacionó con PS y altitud (ALTI) con valores de 0.43 y 0.61, respectivamente. En plantaciones de *Pinus michoacana* Martinez, la COB mostró correlación de 0.82 en relación a la altitud. La ordenación produjo un gradiente ambiental altitudinal-exposicional y, uno de cobertura arbórea; mientras que la ordenación de las variables del sotobosque mostró una tendencia elipsoidal. La clasificación indicó que a un 50% de I (indice de heterogeneidad) se forman dos grupos, uno constituido sólo por *Pennisetum clandestenum* Hoscht. y el otro por el

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resto de las especies. Sólo 10 de las 36 herbáceas mostraron un comportamiento definido respecto a los gradientes encontrados.

Se concluye que *Pennisefum clandestenum* Hoscht. y *Muhlembergia macroaura* (HBK) superan en relevancia ecológica al resto de las herbáceas. No se observa efecto significativo de la práctica de conservación sobre el desarrollo de las especies herbáceas y forestales. Existe baja correlación entre la COB y las variables fisiográficas y dasométricas, independientemente de la plantación forestal. De la tendencia elipsoidal al ordenar a las herbáceas se concluye que pertenecen a una sóla comunidad vegetal, lo cual se confirmó con la clasificación. Sólo 10 especies mostraron respuesta en la COB al gradiente altitudinal-exposicional. Finalmente, se concluye que el sotobosque que crece bajo las plantaciones forestales de la zona oriente de la cuenca de México corresponde a un sólo tipo de comunidad, denominada zacatonal antropogénico y que es una fase detenida de la sucesión vegetal debido a un intenso y prolongado disturbio.

El estudio de cuencas hidrográficas de Chamela, Jalisco: hacia un manejo sostenible del bosque tropical seco

Manuel Maass[1] y Victor Jaramillo[1]

Los bosques tropicales secos, constituyen las áreas más extensas de vegetación tropical del país. Su transformación en campos de cultivo y pastizales se está dando a tasas alarmantes, causando una casi total destrucción de la estructura y composición del bosque, y una profunda modificación de su funcionamiento. En gran medida, esta destrucción se debe a la ausencia de un apropiado enfoque ecosistémico en los programas de explotación.

El enfoque ecosistémico enmarca al problema del manejo y conservación de los recursos naturales en una perspectiva holista, cuyas implicaciones no deben ser subestimadas:

1. El ecosistema, en su conjunto, se convierte en el objeto de explotación y/o conservación;
2. En los programas de manejo y conservación, los aspectos funcionales del sistema cobran prevalencia sobre los aspectos estructurales;
3. La sostenibilidad en el manejo se analiza en escalas espaciotemporales por encima del sistema que se explota;
4. Los balances en los flujos de materia y energía, hacia adentro y afuera del sistema, se identifican como criterios apropiados de sostenibilidad; y
5. Las cuencas hidrográficas se constituyen como importantes unidades de estudio, manejo y conservación de los ecosistemas.

El Centro de Ecología de la Universidad Nacional Autónoma de México (UNAM) con el asesoramiento y colaboración del Laboratorio Hidrológico de Coweeta (USDA-FS) estableció en 1981 un estudio a largo plazo (20-30 años) para entender la estructura y el funcionamiento del bosque tropical seco. E1 estudio tiene tres etapas:

1. El análisis del ecosistema en condicio-nes naturales,
2. El análisis de la respuesta del ecosistema a diferentes tipos e intensidades de manejo, y
3. El análisis del patrón de recuperación una vez cesada la perturbación.

Un importante objetivo del proyecto es desarrollar prácticas de manejo y conservación ecológicamente sostenibles. El estudio se realiza en la Estación de Biología de la UNAM, en la costa del Estado de Jalisco, México.

El proyecto tiene un enfoque fuertemente ecosistémico, en el que balances, bancos y flujos internos de agua, energía y nutrientes, están siendo analizados en 5 pequeñas cuencas hidrográficas experimentales (entre 12 y 28 hectáreas cada una).

Entre los efectos ecológicos que se han detectado y documentado sobre esta transformación de selvas tropicales secas en cultivos anuales y pastizales, se pueden citar:

1. Disminución en la biodiversidad;
2. Pérdida de recursos naturales potenciales al destruir, casi en su totalidad, el bosque;

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3. Cambios en el albedo y por tanto en el microclima de la capa limítrofe;
4. Reducción en la cubierta vegetal, lo que promueve el encostramiento del suelo y una impor-tante reducción en su capacidad de infiltración;
5. Modificación del ciclo hídrico, aumentando la escorrentía superficial, la erosión del suelo, el riesgo de inundaciones y reduciendo la disponi-biliad de agua para las plantas, al igual que la recarga de acuíferos;
6. Cambio en la disponibili-dad de nutrientes en el suelo, debido al efecto combinado de adición de minerales de la vege-tación quemada, y el cambio del ambiente edáfico debido al sobrecalentamiento del suelo;
7. Pérdida de nutrientes del ecosistema como resultado de la volatilización de elementos minerales durante el fuego, la erosión y la lixiviación; y
8. Reducción en la capacidad productiva del ecosistema, inicialmente mejorada por el aumento de luz y nutrientes en el suelo, pero rápidamente disminuida debido a la degradación edáfica.

Cualquier intento de desarrollar estrategias de manejo sostenible del bosque tropical seco deberá tomar en cuenta sus características estructurales y funcionales, tales como su gran diversidad biológica, su alto potencial de especies útiles, su amplia capacidad para regenerarse por rebrotes, su deficiencia en fósforo disponible y su alta vulnerabilidad al proceso de erosión edáfica.

Manejo integral de la flora útil en la comunidad "El Cuarenteño" de la reserva ecológica, "Sierra de San Juan", Nayarit, México

Lidia Susana Ibarra Sánchez, Gilberto González Rodríguez y Sergio Alvarado Casillas

El presente trabajo de investigación se realizó en el ejido "El Cuarenteño", municipio de Xalisco, Estado de Nayarit, México; debido a su localización geográfica, ya que se encuentra ubicado dentro de la Sierra de San Juan y es uno de los poblados que existen dentro de la reserva "Sierra de San Juan" con mayor relación con su medio.

El mantenerse alejados de la ciudad les permite tener mayor contacto con su entorno. Las actividades primarias se realizan dentro del Bosque Mesófilo de Montaña, ecosistema que rodea a la mencionada población; y del cual han obtenido infinidad de productos naturales a lo largo de las diferentes épocas, conllevando con esto a un conocimiento tradicional de la flora, teniendo un muy particular uso y manejo de este tipo de vegetación, manteniendo un nivel de adaptación con su ambiente, que les ha permitido sostener y conservar estos recursos.

Bajo este contexto, se contempla la necesidad de rescatar estos conocimientos etnobotánicos, pues mediante ellos se deduce la importancia de cierto tipo de plantas, su utilización y aprovechamiento y, coadyuvaría a la conservación de potencial genético regional, susceptible a utilizarse de manera racional.

De la investigación etnobotánica realizada, se detectaron 5 categorías antropocéntricas (de uso) de la flora, siendo éstas las siguientes:

- Alimenticias
- Medicinales
- Ornamentales
- Maderables (construcción, combustible y utensilios agrícolas)
- Otros usos

De las cuales se obtuvieron un total de 180 especies, pudiendo en algunos casos presentar dos usos distintos.

Estas plantas se clasificaron por su naturaleza, en silvestres o cultivadas, encontrándose que la mayoría de las plantas utilizadas eran silvestres; pues son colectadas para su consumo en el bosque que circunda al poblado.

Para cada especie se tomaron en cuenta aspectos etnobotánicos como nombre local, parte utilizada, objetivo de uso, forma de preparación, forma de administración, así como datos biológicos tales como: naturaleza, forma biológica, orígen geográfico, entre otros. Toda esta información se concentra en cada una de las tablas de las categorías antropocéntricas para un mejor manejo de los resultados.

Estudio sinecológico del bosque de oyamel de la Cañada de Contreras, Distrito Federal México

Cecilia Nieto de Pascual-Pola[1]

El oyamel [*Abies religiosa* (HBK) Schl . & Cham.] es la especie dominante de su género en la Cuenca de México, y representa una conífera principal de la vegetación forestal ubicada al suroeste del Distrito Federal. En 1993 se realizó un levantamiento fitoecológico del bosque de oyamel en la Cañada de Contreras, en la Delegación Política Magdalena Contreras.

Los objetivos se orientaron a caracterizar la composición florística, forestal y edáfica de la comunidad, así como reconocer el estado de salud que guarda la población forestal.

Los métodos utilizados fueron: colecta botánica, evaluación dasométrica, muestreo edáfico y detección de síntomas de deterioro en follaje y fuste, principalmente. Se aplicaron técnicas convencionales de determinación florística y de análisis de suelos, además de pruebas estadísticas de asociación.

Los resultados indican una comunidad con la diversidad florística propia del oyametal, con predominio de compuestas, compartiendo especies para los bosques de la Sierra del Ajusco. Su distribución altitudinal está limitada de los 2,930 a los 3,400 msnm; y la especie se establece preferentemente sobre pendientes superiores al 30%, donde las masas lucen más vigorosas; su disposición espacial es irregular.

Crece sobre suelos profundos y ricos en materia orgánica, de textura franco-arenosa, con rocosidad media del 18%. Existen pocos árboles de gran altura (35 m), y un predominio de alturas medias y de coberturas reducidas. No se encontraron oyameles en los estratos inferiores, por lo que se supone una pobre regeneración natural.

La proporción de árboles sanos y enfermos es cercana al 50%, y los síntomas de daño más frecuentes son la defoliación y la desramación, que aunado a otras características foliares presentes, se identifican con el efecto del ozono

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Especies silvestres con potencial ornamental del Estado de San Luis Potosí

Felicidad García Sánchez[1]

La diversidad fisiográfica, climática y edáfica en el Estado de San Luis Potosí, ha dado como resultado diferentes formaciones vegetales, que se han agrupado en 13 tipos principales y que a grandes rasgos son: bosque, mezquital, matorral y zacatal (Rzedowski, 1965) y cuya composición florística aún no ha sido totalmente estudiada.

Dentro del estado, numerosas especies han sido explotadas ya sea como alimenticias (flores, frutos y semilllas), forrajeras, para construcción, carpintería, por sus fibras, como ornamentales, medicinales, etc.

Sin embargo, el hombre la mayor de las veces ha aprovechado el recurso en forma irracional, provocando una seria disminución en la población de numerosas especies. Por lo que es conveniente conocer y aprovechar la riqueza florística de las diferentes regiones del estado (e1 Altiplano, la Zona Media y la Zona Huasteca) en las que es posible detectar en mayor o menor número, especies susceptibles de ser utilizadas como ornamentales y hacer posible su domesticación, contribuyendo así a la propagación y conservación de las mismas.

Se realizaron colectas botánicas al área de estudio, los ejemplares fueron herborizados y otros se mantienen en macetas, lo que permitirá conocer su adaptación fuera de su medio natural.

Se proponen:

Altiplano (zona semiárida)

Bauhinia coulteri	Leguminosae
Coryphanta sp.	Cactaceae
Echinocereus pectinatus	Cactaceae
Thelocactus hexaedrophorus	Cactaceae
Oenothera sp.	Onagraceae
Zephyranthes sp.	Amaryllidaceae

Zona Media

Ceratozamia zaragozae	Zamiaceae
Cornus sp.	Cornaceae
Pinguicola marophylla	Lentibulariaceae
Taxus globosa	Taxaceae

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Proyecto de plantaciones forestales en la cuenca de los Lagos de Pátzcuaro y de Zirahuén, Michoacán

Arnulfo Aldrete[1]

En la región forestal que circunda las cuencas de los Lagos de Pátzcuaro y de Zirahuén, en la parte central del Estado de Michoacán, el aprovechamiento forestal forma parte importante de la actividad cotidiana de los productores; sin embargo, el manejo que se ha hecho de los recursos forestales ha provocado una situación importante de deterioro ecológico, debido principalmente a la constante desforestación de esas áreas.

El principal antecedente que se tiene al respecto, es que se ha tratado de reducir el impacto de este problema a través de programas de reforestación; sin embargo, en la mayoría de las ocasiones no se han tenido los resultados esperados, principalmente debido a la falta de control en las diferentes etapas de los programas de reforestación y a que no se ha utilizado la tecnología y ni las especies forestales más adecuadas de acuerdo a las características de la región.

Ante esta problemática, el presente proyecto está encaminado a tratar de contribuir a frenar el proceso de degradación de los recursos naturales en la región por causa de la desforestación, mediante la experimentación de diferentes técnicas y metodologías de control y evaluación de cada una de las etapas involucradas en los programas de reforestación.

La metodología para la realización de este proyecto incluye básicamente tres grandes etapas: la primera consiste en la identifcación y selección de áreas semilleras de las principales especies forestales de la región y el proceso de recolección de semilla de árboles genéticamente superiores de esas áreas; la segunda etapa consiste en la producción de plantas en vivero y la experimentación sobre sistemas de producción y su efecto sobre sobrevivencia y crecimiento de las plantas en campo; y finalmente la tercera etapa consiste en el establecimiento y evaluación de plantaciones forestales, donde se pretende determinar los sistemas y épocas de plantación más adecuados para las especies utilizadas en la región.

Los resultados parciales del proyecto, indican que hasta la fecha se encuentra concluida la primera etapa y consistió en la recolección y evaluación de germoplasma de las cinco principales especies forestales de la región, destacando el *Pinus michoacana* var. *cornuta* y el *Pinus pseudostrobus*. Se espera que los resultados finales de este proyecto proporcionen importante información para ser utilizada en la planeación y ejecución de los programas de reforestación en ésta y otras regiones del país. Además, se espera que las plantaciones que se establezcan, se conviertan en areas experimentales y demostrativas para lograr más eficientemente la transferencia de tecnología por parte de las instituciones involucradas en el subsector forestal y permitir un aprovechamiento sustentable y racional de los recursos naturales.

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Efecto del aprovechamiento forestal en la compactación de un suelo volcánico

Armando Gómez G[1] y Klaudia Oleschko L[1]

El trabajo se llevó a cabo en Nuevo San Juan Parangaricutiro, Michoacán, México. Los suelos del área presentan una capa superficial de cenizas volcánicas y se ubican en el gran grupo Udivitrand, de la clasificación americana.

Este estudio tuvo dos objetivos:

1) evaluar la compactación del suelo en un bosque de pino después del aprovechamiento forestal, y

2) examinar e interpretar variogramas de la resistencia mecánica del suelo.

Se evaluaron las condiciones del suelo en 10 áreas donde se realizó una corta de regeneración, con el método de árboles padres. El método de extracción fue el tradicional, empleando la motogrúa, que es el equipo más común en México. Las áreas testigo se establecieron en lugares cercanos a los de la corta, considerando áreas con la mínima perturbación posible. En cada lugar se midió la resistencia a la penetración (RP) del suelo, con un penetrómetro Proctor. Las mediciones se realizaron en las intersecciones de una malla regular de 40 x 40 metros, con distancia de 10 metros entre línea y línea. Simultáneamente, se obtuvieron muestras para determinar el contenido de humedad por el método gravimétrico (105 °C) en los 10 centímetros del suelo superficial.

Se obtuvieron, mediante el uso de resina sintética, muestras de suelo inalteradas. Sobre éstas se midió el tamaño de agregado y poro, empleando un microscopio y un analizador de imágenes. Los variogramas se estimaron con el algoritmo Geo-Eas. Para probar la diferencia de medias se utilizo la prueba *t* de Student.

La variable RP fue significativamente diferente en cuatro de los diez sitios. Este parámetro varió de 65.7 a 111.6 KPa. En un caso, el valor de RP fue mayor en el testigo que en el área de corta. El estudio mostró que el aprovechamiento forestal tuvo poco efecto sobre la resistencia mecánica del suelo compuesto por cenizas volcánicas. El diámetro medio de agregado fue mayor en las áreas de corta que en las testigo, resultando estadísticamente signifcativas las diferencias. Este resultado se explica por la compactación del suelo que se manifestó por un incremento en la proporción de agregados mayores, aunque el segundo paso de este proceso podría involucrar la ruptura de agregados. El tamaño de poro no fue estadísticamente significativo al comparar las áreas de corta y testigos. La media de esta variable fluctuó entre 0.26 y 0.31 milímetros. Por otra parte, no se encontró una relación entre RP y el contenido de humedad del suelo. Los variogramas obtenidos indican que un espaciamiento óptimo de muestreo para la variable RP podría ser de 40 metros. La tendencia irregular de otros variogramas obtenidos probablemente se explica por el tamaño pequeño de muestra empleado en este estudio.

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Indice de deterioro forestal como base del manejo sustentable en la selva baja cadufolia

Columba Monroy[1] y Rafael Monroy[1]

La estadística mundial señala la relevancia de la vegetación como fuente de energía; en este sentido, la selva baja caducifolia no es ajena a este disturbio. En consecuencia, es importante determinar cuantitativamente los efectos ecológicos de la extracción de leña, para lo cual se presenta la cartografía obtenida con base en el índice de deterioro forestal.

En ésta se ubican las zonas que por su densidad y cobertura son críticas y donde entre otras cosas, se debe intentar su regeneración y manejo sustentable.

Los resultados obtenidos contribuirán a delimitar el área bajo influencia de dicho proceso en un segundo nivel, y consecuentemente los niveles de responsabilidad en proyectos de manejo con sustentabilidad ambiental.

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Impacto de la reforestación sobre la erosionabilidad de suelo

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En una plantación con *Pinus halepensis* ubicada en la Sierra Zapalinamé del Estado de Coahuila, se condujo un estudio con el objeto de evaluar el impacto de la vegetación establecida por reforestación, en algunas propiedades físicas que afectan la erosionabilidad del suelo y su relación con la producción de sedimentos. Los sitios bajo estudio fueron: plantación de 30 años, plantación de 18 y un sitio sin reforestar que sustentaba vegetación de gramineas.

Se utilizó un simulador de lluvia del tipo aspersor para aplicar durante treinta minutos una lluvia de 98.5 mm/hr, sobre parcelas circulares de un metro de diámetro; en cada sitio se realizaron seis pruebas de simulación. Se cuantificó el escurrimiento superficial y los sedimentos producidos fueron obtenidos por filtración.

Para estimar la susceptibilidad del suelo a la erosión se utilizó la ecuación de erosionabilidad de Wischmeier *et al.* (1971), que involucra los siguientes factores: contenido de arenas gruesas, limos + arenas finas, contenido de materia orgánica, estructura (código asignado en función del tamaño de los agregados del suelo) y permiabilidad (código que depende de la velocidad de infiltración). Además se evaluó la estabilidad de agregados del suelo con el tamizado en húmedo, utilizando el diámetro medio geométrico (DMG) para expresar el índice de agregación.

Se obtuvo una matriz de correlación entre las variables estudiadas y se realizaron análisis de varianza asumiendo una distribución completamente al azar. Los resultados indican que existen diferencias entre tratamientos para el factor erosionabilidad (K), a un nivel de significancia de 0.093 donde su valor varió de 0.0045 a 0.01122 (tonhahr/MJmmha) en árboles maduros y sitios sin reforestar respectivamente.

Existió una correlación altamente significativa de la erosionabilidad del suelo con el escurrimiento superficial (r = 0.749) y con la producción de sedimentos (r = 0.779). En la estabilidad de agregados, el índice de agregación mostró diferencias significativas mas allá del nivel 0.01 y fue mayor en el sitio reforestado con árboles maduros (DMG = 1.526) que en los sitios con árboles jovenes (DMG = 0.815) y sin reforestar (DMG = 0.816). La relación entre el índice de agregación y la producción de sedimentos fue negativa (r = - 0.409). La variable que presentó mayor relación con el índice de agregación fue el mantillo orgánico (r = 0.704).

Se concluye lo siguiente: la vegetación establecida por reforestación incrementa significativamente la estabilidad de agregados del suelo. El factor erosionabilidad no presentó diferencias significativas a un nivel 0.05, sin embargo guardó relaciones con la lámina de escurrimiento y la producción de sedimentos. Se reconoce la importancia de la vegetación establecida por reforestación en la modificación de las propiedades del suelo que influyen en la erosión hídrica.

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Análisis genético del mezquite (*Prosopis spp.*) por medio de la reacción en cadena de la polimerasa

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El mezquite, tiene amplia distribución geográfica en las zonas áridas y semiáridas de México y reviste gran importancia en las cadenas tróficas de los ecosistemas además a de tener gran valor utilitario. A pesar de que los estudios taxonómicos actuales han brindado magníficos resultados para diferenciar las especies del género *Prosopis*, existe una amplia plasticidad fenotípica que confunde notablemente a los taxónomos aún al utilizar taxonomía numérica, quimiotaxonomía, citotaxonomía, electroforesis de proteínas de reserva y de isoenzimas.

El propósito de la presente investigación es detectar diferencias o similitudes genéticas a través de la Reacción en Cadena de la Polimerasa (PCR). Una variante sencilla y reproducible de la PCR, conocida como Amplificación al Azar de DNA polimórfico (RAPDs), que permita el análisis del DNA, y que sirva de apoyo a la sistemática para discernir problemas taxonómicos entre las especies del género *Prosopis*.

Con el propósito de captar la mayor variabilidad ecológica de distribución del género *Prosopis* en Nuevo León, México, se trazó una ruta de muestreo que incluyó altitudes de 120 a 1750 msnm, obteniéndose 12 especímenes para este estudio. El criterio de selección además del ecológico, fue que presentaran rasgos morfológicos variables. Las muestras colocadas se prepararon para su análisis en el laboratorio de Patología Molecular del Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP). El protocolo para la extracción de DNA fue adoptado de Dallaporta *et al.* (1985). Se utilizó la técnica de Amplificación al azar de DNA polimórfico (RAPD), la cual ofrece las ventajas de rápidez, simplicidad y altas frecuencias de identificación de polimorfismos. Esta metodología esta basada en la PCR y provee un nivel de resolución equivalente a PFLPs e isoenzimas en la determinación de las relaciones genéticas entre genotipos. Las PCRs se llevaron a cabo en volúmenes totales de 50 ul por muestra, en la cual se incluyó 200 ng de DNA, 10 pM de cada iniciador, 200 mM de cada desoxinucleótido, 5 ul de buffel de polimerización 10x, 3.0 mM de $MgCl_2$ y 2.5 unidades de DNA polimerasa Tag. La reacción se realizó en un termociclador (Perkin Elmer) por medio de 34 ciclos con temperaturas de 94 °C durante 1 min., 36 °C durante 1 min. y 72 °C por ese mismo tiempo. Los productos amplificado fueron fraccionados utilizando electroforesis en geles de 1.5% agarosa y/o de poliacrilamida al 8%. La tinción se realizó con bromuro de etidio, y la reacción analizada por observación del gel bajo luz ultravioleta.

La variabilidad fenotípica de las especies se agrupó mediante taxonomía convencional en: *Prosopis laevigata*, *P. glandulosa* var. *glandulosa*, *P. glandulosa* var. *torreyana* y *P. glandulosa* var. *prostrata*. Los resultados de las amplificaciones al azar de fragmentos de DNA utilizando dos iniciadores de 21 nuclotidos, amplificaron hasta 8 bandas por genotipo. Estos iniciadores no amplificaron para *Leucena* spp, *Cocus nucifera* y *Citrus auriantum*, lo que indica especificidad

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para *Prosopis*. De acuerdo al número de bandas y su especificidad molecular se presentaron solo dos grupos, que relacionándolos con la clasificación taxonómica posiblemente el material colectado se agrupe en solo dos especies *P. glandulosa* y *P. laevigata*, considerando que la técnica de RAPDs es útil para la detección de variabilidad dentro de rangos restringidos de diversidad será importante continuar las investigaciones con los *Prosopis* de México para generar marcadores genéticos de cada especie que permita identificar la variabilidad y además explorar la introgresión genética entre las especies. Estos resultados ampliarán el conocimiento del material genético y el aprovechamiento de los genes deseables del mezquite, para futuros programas en *Prosopis*.

La amplia plasticidad fenotípica en *Prosopis* fue posible agruparla usando PCR en dos especies de las cuatro que se identificaron taxonómicamente en la presente investigación. La técnica de RAPDs fue sensible para descriminar entre especies de acuerdo al patrón de electroforesis.

Los procesos de actualización de la cartografía del Instituto Nacional de Estadística, Geografía e Informática (INEGI)

Francisco Takaki Takaki[1]

El Instituto Nacional de Estadística, Geografía e Informática (INEGI) tiene, entre otros objetivos, el de producir la información que el país requiere para planificar y favorecer el aprovechamiento óptimo de sus recursos naturales. Es así, que el INEGI ha realizado diversos grados de cubrimiento cartográfico del territorio nacional, en diferentes escalas y temas, como las cartas topográfica, geológica, de uso del suelo y vegetación, hidrológica, edafológica, etc. Estas cartas han sido elaboradas por procesos tradicionales (manuales) de fotogrametría y fotointerpretación, relativamente lentos para los requirimientos actuales de información, por lo que se buscaron alternativas para su agilización.

El desarrollo tecnológico para el procesamiento digital de información geográfica, ha permitido al INEGI diseñar y estructurar el Sistema Nacional de Información Geográfica (SNIG), que se basa en las siguientes funciones:

- Capturar datos, mapas e imágenes existentes.
- Producir y actualizar la información cartográfica.
- Almacenar y recuperar la información, de manera selectiva, confiable y eficiente.
- Procesar los datos usando herramientas estadísticas y de análisis espacial.
- Procesar en pantalla y generar resultados con calidad de edición cartográfica.
- Supervisar y controlar la operación en general.

En el presente cartel, se presenta de manera gráfica, los diferentes pasos que se siguen en la actualización de la carta topográfica a escala 1:50,000 y de la carta de uso suelo y vegetación a escala 1:1´000,000.

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Sistemas agroforestales con *Gliricidia sepium*; una alternativa para controlar la erosión de los suelos

W. López Baez[1], R. Camas Gómez[1] y J. López Martínez[1]

En general, los trabajos de conservación de suelos y agua, no han alcanzado los resultados esperados debido a la promoción de técnicas complejas y costosas, difíciles de adoptar por los agricultores. En México, el Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), ha desarrollado investigaciones sobre tecnologías fácilmente adaptables a las circunstancias de los agricultores y con alta eficiencia para sustentar la productividad y conservar los recursos naturales.

Con este enfoque se han estudiado los sistemas agroforestales (SAF), bajo la variante de "cultivos en callejones" que consisten en la introducción de hileras de árboles de *Gliricidia sepium*, en forma de franjas intercaladas al cultivo de maíz; esta especie es una leguminosa nativa de México, utilizada en los sistemas agroforestales por su fácil propagación, ya sea por semillas o estacas, su manejo a través de rebrotes o podas de copa y por su capacidad de fijar nitrógeno. A la fecha se ha generado información sobre el establecimiento, manejo y mantenimiento del sistema para el trópico seco.

Experimentos establecidos en pendientes de 30-40% han estimado que los SAF reducen la pérdida de suelo en 70% en el primer año y los escurrimientos en 44%; a partir del segundo y tercer años, cuando el material de poda de la *Gliricidia* ya reforzó el cerco, la pérdida de suelo se reduce hasta 90% y el agua escurrida hasta el 78%. Ésto representa una disminución de la contaminación del agua con sedimentos, de 40% en el primer año y hasta del 90% en el segundo año.

En parcelas de validación a partir del primer año, el suelo retenido detrás de la barrera tiene un espesor de 10 centímetros en pendientes de 6-10% y de 24 centímetros cuando es de 20-40%; este movimiento del agua y el consecuente depósito de partículas de suelo en la base de los cercos, originarán paulatinamente una terraza natural.

En el área cercana a las barreras, la humedad ha sido 6% mayor en la época de sequía intraestival, en comparación con las parcelas donde no se ha establecido el SAF; esto se debe al profundo sistema radical de la *Gliricidia* y lo denso del cerco, que promueven la infliltración del agua por la concentración escurrimiento en zonas determinadas, este efecto puede aumentarse, si se hace un adecuado manejo de los residuos de cosecha y plantas de cobertera.

Las barreras con dos años de establecidas producen hasta 250 kilogramos de leña por cada 100 metros lineales. En conclusión el SAF con *Gliricidia*, es un método vegetal de conservación de suelo y agua, que hace uso la naturaleza para su propia protección, introduce pocas modificaciones al sistema tradicional de los agricultores y tiene una alta adopción potencial.

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Producción de hongos comestibles en bosques templados de hidalgo, Puebla y del Distrito Federal

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En los bosques templados de México existe una gran diversidad fúngica, la cual incluye a numerosas especies comestibles con valor de uso y/o de cambio entre la población rural. Actualmente se tiene un registro de 210 taxa comestibles, de ellas sobresalen por su demanda en el mercado nacional e internacional: *Tricholoma magnivelare*, *Morchella* spp., *Amanita caesarea*, *Boletus edulis* y *Cantharellus cibarius*, entre otras.

Sin embargo, son escasos los datos documentados sobre la producción natural por especie, información que es básica para llevar a cabo el manejo sostenible de las poblaciones fúngicas, el que a su vez representa una alternativa promisoria dentro del manejo integral de los ecosistemas forestales.

En este contexto, el Instituto Nacional de Investigaciones Forestales y Agropecuarias a través del CENID-COMEF, durante los últimos cuatro años ha realizado evaluaciones de la producción de hongos comestibles en los Estados de Puebla, Hidalgo y en el Distrito Federal, para ello se han establecido parcelas de muestreo permanentes en bosques de *Abies religiosa*, *Pinus montezumae* y *Pinus teocote* - *Quercus* spp., en las cuales se han recolectado y obtenido el peso fresco correspondiente de los carpóforos presentes durante al menos dos temporadas continuas. Así mismo se ha realizado la caracterización ecológica de las regiones estudiadas.

A la fecha se cuenta con la estimación por hectárea para aproximadamente 50 especies de hongos comestibles, entre los que sobresalen: *Boletus edulis*, *B. aestivalis*, *Amanita caesarea*, *Russula brevipes*, *R. queletti*, *Gomphus floccosus*, *Ramaria flava*, *Lactarius deliciosus* y *Laccaria amethystina*. Además se cuenta con la etimación del valor económico de la producción fúngica por región estimada, los cuales oscilan entre N$238.32/ha a N$500.00/ha (bosque de pino) y en el oyametal alcanza un valor de N$1,199.80/ha; el período de aparición de los carpóforos varía en función de las condiciones ecológicas de cada región, pero en general comprende de cuatro a cinco meses, a partir del mes de junio.

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Determinación de la durabilidad natural de tres maderas tropicales al ataque de hongos xilófagos

María Guadalupe Lomelí Ramírez[1] y Luis Ramón Bravo García[1]

INTRODUCCION

El papel que desempeñan los hongos xilófagos en la naturaleza es la degradación del material leñoso a formas orgánicas simples, pero cuando el ataque se presenta en árboles vivos, madera aserrada o en productos terminados, esta actividad es perjudicial, causando las llamadas pudriciones de la madera, lo que provoca cuantiosas pérdidas económicas a la industria forestal, a la mueblera (afectando las propiedades físico-mecánicas y estéticas de los productos) y a la maderera en general.

Sin embargo, existen especies de clima templado, pero sobre todo de clima tropical, que poseen marcada resistencia o durabilidad natural al ataque de hongos xilófagos. Esta resistencia a la pudrición se ve influenciada por la presencia de ciertos extractivos con propiedades fungitóxicas, causales de tal efecto sobretodo en madera de duramen. Y para conocer el efecto inhibitorio de estos extraibles se realizan las pruebas rápidas de laboratorio, que nos dan a conocer la susceptibilidad o resistencia de la madera a la pudrición por hongos xilófagos y por lo tanto dar un uso tecnológico más adecuado a ésta.

MATERIALES Y METODOS

Las especies de estudio fueron: *Hura polyandra* Baill. (habillo), *Enterolobium cyclocarpumn* (Jacq.) Griseb. (parota), *Cordia eleagnoides* D. C. (barcino) y la especie de referencia utilizada fue *Spondias mombin* L., colectadas en Tomatlán, Jalisco y Bucerías, Nayarit; las cuales se enfrentaron a los hongos xilófagos: *Lentinus lepideus* Fr. que causa pudrición parda y *Laetiporus sulphureus* (Bull.: Fr) Murr. causante de pudrición blanca.

Utilizando para ello 2 metodologías diferentes: método estandar ASTM Designación D2017 71 (bloque-suelo) y el segundo denominado caja-petri (Wang y Col., 1980).

RESULTADOS

Por el método ASTM se observó una pérdida de peso de la madera de barcino de 27.37% con relación al habillo que fue de 22.73% y para la parota de 21.37%, por lo que el barcino se clasificó como moderadamente resistente, mientras que el habillo y la parota como resistentes ante el ataque del hongo *Laetiporus sulphureus* y para *Lentinus lepideus* las pérdidas de peso de las maderas fueron: habillo 18.07%, parota 16.75% y barcino 12.55%, clasificándose todas como resistentes.

Por el método caja-petri, se volvió a comprobar la resistencia a la pudrición de las maderas ensayadas; los mejores resultados fueron para la parota y barcino, en ese orden, y por último el habillo.

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Estudio de plantas ornamentales silvestres con alto potencial genético, como una alternativa de producción en la reserva ecológica Sierra de San Juan

Sergio Alvarado Casillas y Lidia Susana Ibarra Sánchez

El presente trabajo de investigación consistió en un estudio sobre plantas silvestres procedentes de la reserva ecológica Sierra de San Juan, las cuales debian de poseer características ornamentales para poder ser colectadas.

Se localizaron algunas zonas de la reserva ecológica de la Sierra de San Juan con especies vegetales de alto potencial ornamental, como son: las comunidades Adolfo López Mateos, El Cuarenteño, El Malinal y San Antonio.

Los sitios de colecta se ubicaron en un gradiente de 900 a 1,400 msnm a lo largo del cual aparecen dos tipos de vegetación predominantes: bosque mesófilo de montaña y bosque de pino-encino.

La metodología del trabajo consistió en colectas y determinación taxonómicas del material, alternando las actividades de campo y de gabinete.

El material vegetativo colectado se sometió a pruebas de propagación por diferentes técnicas de reproducción asexual; a la semilla se le hicieron pruebas de germinación para conocer su viabilidad, vigor, así como su velocidad de crecimiento.

El estudio florístico demostró que en la zona de reserva ecológica existen una gran diversidad de especies con características ornamentales, colectándose a 23 familias; entre ellas se localizaron a las Orchidaceae, Acantaceae, Compositae, Musaceae, Convulvolaceae, Palmaceae y Rubiceae, entre otras.

Con base en los resultados, se concluye que los objetivos que se plantearon al inicio de este trabajo se cumplieron en lo siguiente:

- Se localizaron las zonas de la reserva ecológica Sierra San Juan con especies de alto potencial ornamental.
- Se hicieron las colectas e identificación de las diferentes categorías de 23 familias.
- Con este estudio los pobladores, principalmente los de El Cuarenteño, conocieron la importancia de los recursos vegetales con los que cuenta la reserva ecológica Sierra de San Juan; actualmente se está trabajando con un grupo de ejidatarios con el objeto de hacer un vivero para propagar orquideas de esta reserva ecológica, con fines comerciales.

Calidad del agua en al cauce de la cuenca El Carrizal, Tapalpa, Jalisco

Alvin L. Medina[1], Juan De Dios Benavides[2], y Esteban Talavera Z[3]

Un análisis de diversos elementos disueltos en el agua sirven como referencia para conocer la calidad de la misma, a su vez el conocimiento de la calidad del agua funciona como un indicador para identificar el estado de salud y funcionamiento de la cuenca junto con otros factores físicos y bióticos. La calidad del agua puede ser un indicador muy sensible con respecto a los cambios que ocurren en la cuenca relacionados con algún problema de disturbio. El propósito del presente trabajo es:

- el de identificar los elementos mas significativos que puedan indicar algún problema de la calidad de agua y
- el de desarrollar y recomendar algunas practicas que puedan ser aplicables para corregir los problemas que se pudieran presentar.

Muestras de agua tomadas durante la temporada de lluvias fueron analizada el año de 1994. Los parámetros que fueron medidos incluyen: temperatura, pH, conductividad específica, oxígeno disuelto, nitratos y sedimentos suspendidos. También se hicieron análisis fisicoquímicos de potabilidad y bacteriológicos de 7 sitios seleccionado para obtener una vista mas comprensivo de parámetros que pudieran ser mejor indicadores de los procesos que se presentan en la zona ribereña. Los resultados preliminares indican que varios de los elementos evaluados no tuvieron problemas dentro de la cuenca como fueron: los nitratos (<0.4 ppm), sulfatos (5-50 ppm), solidos disueltos (54-73 ppm), y dureza (33-77 ppm), ya que estuvieron por abajo de los limites de las normas mínimas de calidad. La turbidez (9-22 NTU) tuvo variaciones a lo largo de la cuenca pero sin presentar problemas fuertes. El fierro fue un elemento que tuvo alta concentración (2.07 ppm) y mas variación de sitio a sitio en la parte media de la cuenca, aunque todavía no se define exactamente la fuente de la problema, puede ser ocasionado por la minería, caminos o otro factor. También en el total del cauce del riachuelo se observo una presencia alta de coliformes totales (68-480/ml) cuya causa probable sean las heces del ganado que pastorean por la zona ribereña.

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Propuesta de ecosistema para el diagnóstico de condiciones y manejo de ecosistemas ribereñas en la cuenca Del Carrizal, Tapalpa, Jalisco, México

Alvin L. Medina[1], Alberto Gomez Tagle[2], Malchus B. Baker, Jr.[3], and Daniel G. Neary[4]

En México hay un gran desconocimiento sobre la importancia, manejo y sostenibilidad de ecosistemas ribereñas. El manejo de cuencas relacionado con la calidad de agua y la sostenibilidad de los recursos, es de primera importancia tanto para USA como para México. En USA existe un gran cúmulo de conocimientos sobre ecosistemas ribereñas con diversas estrategias que pueden ser formuladas entre modelos de investigación y manejo. Estos ahora pueden ser validados sobre problemas de interés para los dos países. La necesidad de generar este conocimiento, su aplicación hacia la identificación de causas de deterioro de ecosistemas ribereñas, desarrollo de mejores prescripciónes de manejo, y la validación de tecnología, son el objetivo principal del proyecto "El Carrizal".

Una aplicación practica del proyecto de manejo de ecosistemas ribereñas fue implementado y desarrollado en agosto de 1993, conforme a la Carta de Intención (Letter of Intent) entre el USDA Servicio Forestal y SARH-INIFAP. El objetivo principal fue de transferir una tecnología reciente para la restoración y manejo de ecosistemas ribereñas, dentro de la propuesta de manejo de ecosistemas para el asesoramiento y monitoreo en la cuenca experimental. Como objetivos secundarios se plantaron: (1) obtener el inventario, clasificación, y adaptación de protocolos de levantamiento rápido de condiciones de la cuenca usando la vegetación y la morfología canales; (2) interpretar las interacciones básicas de componentes de la cuenca y su relación con la sostenibilidad de los recursos de ella; y (3) desarrollar prescripciónes de restoración para la producción de agua de buena calidad para los residentes.

Por la invitación de los científicos Mexicanos del INIFAP, los científicos del Servicio Forestal, Estación Montañas Rocallosas crearon en colaboración un diagnóstico de la cuenca experimental, "El Carrizal", que esta localizada cerca del la población de Tapalpa, Jalisco. Por los convenios entre INIFAP y Industria Tapalpa, Jal. la implementación de planes, colección de datos y trabajos de campo, etc se hicieron con rapidez. Un reconocimiento completo revelo como actividades o disturbios mayores entre la cuenca: (1) extracción de madera, (2) pastoreo de ganado, (3) extracción en mina de piedra, (4) incendios, (5) caminos que atraviesan corrientes, (6) uso de pastizales intensivos de riego, y (7) desviación de aguas de ribera. Fueron seleccionado sitios de monitoreo y implementado sistemas de colección automática de datos.

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Los científicos Mexicanos concurrieron a entrenamiento intensivo en salón de clase, laboratorio y de campo sobre las siguiente áreas de interés: (1) técnicas de medición para la determinación de calidad de agua y parámetros de cantidad, caracterización y clasificación de la vegetación ribereña, (c) caracterización y clasificación de morfología de canales del rió, y erosión de suelos en el sistemas de caminos; (2) técnicas de biodiagnóstico para sistemas acuáticas; (3) técnicas de restauración para sistemas de caminos forestales; y (4) aplicaciones computadorizadas para diagnósticos de problemas. Cada científico Mexicano de acuerdo fue asignado a un área del proyecto en unión con un científico de Servicio Forestal como guía.

De forma conjunta todos los datos se van a interpretar cuidadosamente usando una propuesta de disciplina integrada, donde todos los miembros del equipo participaran para derivar las recomendaciones finales. Todos los datos serán posteriormente incluidos dentro una base de datos GIS que se esta desarrollando actualmente (Baker et. al., esta publicación) y serán utilizadas como fundamento de "Prácticas de Mejor Manejo" para la cuenca. Se colecta información de tipo básico y para diagnóstico en las siguiente áreas: (1) calidad y cantidad de aguas, (2) lluvia, (3) vegetación ribereña (Medina, 1986), (4) tipos de canales de rió (Rosgen, 1994), (5) macroinvertebratos acuáticos (USDA Forest Service, 1985 y Plafkin et. al. 1989). En menos de 10 meses, fueron colectado suficiente datos para permitir la formulación de hipótesis preliminares sobre la condición de la cuenca. Los resultados se presentan en esta publicación.

El éxito inicial de este proyecto no se puede atribuir a un individuo o hecho, sino a la labor que han realizado todos los miembros del equipo basados en "la confianza a las personas con mayor conocimiento, la realización de las tareas, y un deseo intenso de éxito". Al reunir muchas personas experimentadas con pericias especiales, se creó la experiencia interpersonal que dio el resultado mencionado antes. La camaradería inspiró el trabajo intenso y la dedicación profesional de cada individuo en su área de especialidad, cada miembro desarrolló un convencimiento personal de la importancia en el manejo de áreas ribereñas. Otro punto de importancia en el proyecto es el ingrediente de tipo social que como "química personal" es un elemento esencial en el desarrollo de equipos que son efectivo y motivados mismos.

El proceso utilizado para implementar este proyecto de ecosistema fue con base en la filosofía de Maser (1994) sobre 'Manejo Adaptable de Ecosistemas', donde Maser describe el proceso como uno designado "para el aprendizaje rápido y efectivo por científicos, gerentes, sociedad, y hacedores de póliza y ... para cambios rápidos". Un ejemplo semejante fue empleado al diagnosticar la intensa carga de sedimentos suspendidos en agua del río, originados por el mal estado de los caminos forestales. La tecnología disponible fue transferida (Burns et. al. y Huendo et. al, en esta publicación) y desplegada rápidamente vía entrenamiento de campo por el científico en áreas actuales que tenían problemas. También fueron informados y educados los gerentes y propietarios para lograr su apoyo con recursos humanos y naturales para emplear la tecnología. El resultado esperado es reducir la cantidad de sedimentos que se van al río, mejorar la calidad de agua y reducir los efectos acumulativos en la sistema acuático.

Probablemente uno de los resultados mas importante fue la habilidad de gerentes, propietarios, y cientifícos Mexicanos de reconocer el valor de las ecosistemas ribereñas como componentes extremamente importante del manejo de cuencas. También se reconoció la capacidad de áreas ribereñas para la producción sostenible de agua de buena calidad que en ese lugar es una comodidad rara. Además, quedaron claros los efectos acumulativos del pastoreo, corte de madera, y construcción de caminos como parte importante a implementar en un ecosistema de paisaje Mexicano con usos intensos. El conocimiento desarrollado es critico para cumplir con las demandas crecientes en México de una mejor calidad de vida.

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Insectos acuáticos de la cuenca El Carrizal y sus relacion a la condición de cuenca: El Carrizal, Tapalpa

Alvin L. Medina[1], J. Trinidad Saenz Reyes[2], y Constantino Orduna Trejo[3]

Insectos acuáticos fueron colectado durante la época de lluvia en varios sitios entre la cuenca. Después los insectos fueron identificado por especies. Ya conociendo los especies, se puede predecir la calidad de agua o habitat acuática. Los datos demostran que hay condiciones de calidad de sitios son muy variable, y que problemas con calidad de agua existen con respecto a ciertos sitios y a las actividades de manejo de bosque o pastizales. El asesoramiento preliminario de insectos acuáticos es otro utíl que se usa para determinar la calidad de áreas rebereñas. Sitios que fueron degradado tienen unos especies de insectos indicadores de condiciones del sitio.

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Proyecto de investigacion interdisciplinario del Bosque Experimental Blacks Mountain

William W. Oliver[1]

Uno de los problemas más grandes que el Servicio Forestal enfrenta en estos momentos es el desarrollo, la restauración, y el mantenimiento de los bosques naturales no intervenidos. Se desconoce si las características de estos bosques pueden ser desarrolladas a través de la administración o el manejo de rodales más jóvenes, como tampoco se sabe si podemos manejar rodales no intervenidos con el objeto de restaurar y perpetuar aquéllas características a lo largo del tiempo. Asímismo, las relaciones de productividad y de biodiversidad forestal en lo que respecta a las etapas ecológicas forestales a lo largo del tiempo son totalmente desconocidas.

Con el objeto de encontrar una respuesta a éstas incógnitas, se esta llevando a cabo un proyecto de investigación interdisciplinario a gran escala en el Bosque Experimental Blacks Mountain, el cual se localiza el tipo de pino del lado este del noreste de California. Esta investigación es un acercamiento interdisciplinario a largo plazo. El objetivo de este estudio es determinar como los diferentes componentes del ecosistema responden e interactúan (física y biológicamente) a la restauración de dos condiciones ecológicas forestales distintas en lo que se refiere a como son afectadas por diversos problemas del terreno.

Las estructuras que están siendo creadas son: una de etapa serial tardía (diversidad estructural alta), y la otra, de etapa serial media (diversidad estructural baja). Los tratamientos van a ser repetidos en doce parcelas de 10 ha acres cada una. Además, se implementarán tratamientos suplementarios los cuales van a alterar la estructura del sotobosque y del suelo forestal (cantidad de material muerto y desechos, etc.). Estas dos estructuras constranstantes forestales van a ser desarrolladas y perpetuadas con el ojeto de incrementar la posibilidad de detectar lo siguiente:

- Respuestas a la provisión de carbono
- Cambios en la diversidad genética y biológica
- Relaciones entomológicas, especialmentede los descortezadores escarabajos
- Factores de sostenibilidad, incluyendo incendios periódicos
- Cantidad y diversidad de especies de mamíferos pequeños (incluyendo los migratorios neotropicales) y reptiles
- Respuesta patógena
- Procesos de fertilidad de suelos
- Establecimiento de vegetación y respuestas de crecimiento

Se ha recogido la información básica en lo que respecta a la vegetación, suelos, fauna silvestre e insectos. La historia de incendios ocurridos está siendo determinada a través de los análisis de los anillos de los árboles. Asímismo se está determinando la diversidad genética básica. La información está siendo integrada en un adecuado esquema de muestreo permanente de 100 mts de lado. La información va a ser analizada espacial y temporalmente mediante el uso de un Sistema de Información Geográfica.

Este proyecto permite lograr una estrecha cooperación con las universidades e investigadores de otras agencias y organismos, ereando una oportunidad de investigación de gran alcance y significado. En estos momentos están cooperando con este proyecto científicos de la Michigan Technological University, la Oregon State University de la Intermountain Research Station.

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Calidad del agua en el cauce de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

Alvin L. Medina[1], Juan de Dios Benavides[2] y Esteban Talavera Zúñiga[2]

Un análisis de diversos elementos disueltos en el agua, sirve como referencia para conocer la calidad de ésta, a su vez la calidad del agua es un indicador de la sanidad y funcionamiento de la cuenca junto con otros factores físicos y bióticos. La calidad del agua, puede ser un indicador muy sensible respecto a los cambios que ocurren en la cuenca, relacionados con algún problema de desequilibrio. El propósito del presente trabajo es: 1) Identificar los elementos más significativos que puedan indicar algún problema en la calidad de agua y, 2) Desarrollar y recomendar algunas prácticas que puedan ser aplicables para corregir los problemas que se pudieran presentar. Fueron analizadas muestras de agua tomadas durante la temporada de lluvias de 1994.

Los parámetros medidos incluyen: temperatura, pH, conductividad específica, oxígeno disuelto, nitratos y sedimentos suspendidos. También se hicieron análisis físico-químicos, de potabilidad y bacteriológicos en 7 sitios seleccionados para obtener un panorama más amplio de los parámetros que pudieran ser mejores indicadores de los procesos que se presentan en la zona ribereña.

Los resultados preliminares indican que varios de los elementos evaluados no tuvieron problemas dentro de la cuenca, como fueron: los nitratos (< 0.4 ppm), sulfatos (5-50 ppm), sólidos disueltos (57-73 ppm) y dureza (33-77 ppm), ya que estuvieron por abajo de los límites mínimos de las normas de calidad. La turbidez (9-22 NTU) tuvo variaciones a lo largo de la cuenca, sin presentar problemas fuertes. El fierro fue el elemento que tuvo mayor concentración (2.07 ppm) y la más alta variación de un sitio a otro en la parte media de la cuenca. Aún no se define la fuente del problema, ya que puede ser ocasionado por la minería, caminos u otro factor. En todo el cauce del arroyo, se observó alta presencia de coliformes totales (68-480/ml) cuya causa probable son las heces del ganado que pastorea en la zona ribereña.

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Propuesta de proyecto para el diagnóstico de condiciones y manejo de ecosistemas ribereños en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

Alvin L. Medina[1], Alberto Gómez-Tagle Rojas[2], Malchus B. Baker, Jr.[3] y Daniel G. Neary[4]

En México hay un gran desconocimiento de la importancia, el manejo y la sostenibilidad de los ecosistemas ribereños. El manejo de cuencas relacionado con la calidad del agua y la sostenibilidad de los recursos, es de la mayor importancia tanto para Estados Unidos de América (EUA) como para México. En EUA existe un gran cúmulo de conocimientos sobre ecosistemas ribereños con diversas estrategias que pueden ser formuladas en modelos de investigación y manejo. Éstos ahora pueden ser validados en problemas de interés para los dos países. Los objetivos principales del proyecto de la cuenca del arroyo El Carrizal son generar este conocimiento y su aplicación para la identificación de las causas de deterioro de ecosistemas ribereños, el desarrollo de mejores propuestas de manejo y la validación de tecnología.

En agosto de 1993 fue instrumentada y desarrolladauna aplicación práctica del proyecto de manejo de ecosistemas ribereños , conforme a la Carta de Intención (Letter of Intent) entre el USDA Servicio Forestal y la SARH-INIFAP. El objetivo principal fue el de transferir una tecnología reciente para la restauración y el manejo de ecosistemas ribereños, dentro de la propuesta de manejo de ecosistemas para la evaluación y el monitoreo en la cuenca experimental. Como objetivos secundarios se plantearon:

1. Obtener el inventario, clasificación y adaptación de métodos de levantamiento rápido de las condiciones de la cuenca, usando la vegetación y la morfología de canales;
2. Interpretar las interacciones básicas de los componentes de la cuenca y su relación con la sostenibilidad de los recursos de ella y;
3. Desarrollar prescripciones de restauración para la producción de agua de buena calidad para los habitantes locales.

Los investigadores mexicanos del INIFAP y los del Servicio Forestal de la estación Experimental Forestal y de Manejo de las Montañas Rocallosas, desarrollaron en colaboración un diagnóstico de la cuenca experimental del arroyo El Carrizal, que está localizada cerca de la población de Tapalpa, Jalisco. mediante los convenios entre INIFAP y la Industria Forestal de Tapalpa, el desarrollo de planes, la obtención de datos y los trabajos de campo, se hicieron con

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rápidez. Un reconocimiento completo, revelo como actividades o disturbios mayores dentro de la cuenca los siguientes:

1. La extracción de madera;
2. El pastoreo de ganado;
3. La extracción de piedra de minas a cielo abierto;
4. Los incendios forestales;
5. Los caminos que atraviesan arroyos;
6. El uso intensivo de sistemas agropastoriles no planeados y;
7. La desviación de aguas de la ribera.

Se seleccionaron sitios de monitoreo y se desarrollaron sistemas de colección automática de datos. Los investigadores mexicanos concurrieron a entrenamiento intensivo de gabinete, laboratorio y campo sobre las siguientes áreas de interés:

1. Técnicas de medición para la determinación de calidad de agua y parámetros de cantidad, caracterización y clasificación de la vegetación ribereña; caracterización y clasificación de morfología de canales; y erosión de los suelos en los sistemas de caminos forestales;
2. Técnicas de biodiagnóstico para sistemas acuáticos;
3. Técnicas de restauración para sistemas de caminos forestales y ;
4. Aplicaciones computarizadas para diagnósticos de problemas.

Cada investigador mexicano fue asignado a un área del proyecto en colaboración y bajo la guía de uno del Servicio Forestal.

En forma conjunta todos los datos se interpretan cuidadosamente, mediante una propuesta de disciplina integrada, donde todos los miembros del equipo participarán para derivar las recomendaciones finales. Todos los datos serán posteriormente incluidos dentro de una base de datos SIG que se está desarrollando actualmente (Baker *et al.*, 1995) y serán utilizadas como fundamento de "Prácticas para mejorar el manejo de la cuenca". Se colecta información de tipo básico y para diagnóstico en las siguientes áreas:

1. Calidad y cantidad de agua;
2. Lluvia;
3. Vegetación ribereña (Medina, 1986);
4. Tipos de canales (Rosgen, 1994); y
5. Macroinvertebrados acuáticos (USDA Forest Service, 1985 y Plafkin *et al.*, 1989).

En menos de 10 meses, fueron colectados suficientes datos para permitir la formulación de hipótesis preliminares sobre la condición de la cuenca. Los resultados se presentan en esta publicación.

El éxito inicial de este proyecto no se puede atribuir a un individuo o hecho, sino a la labor que han realizado todos los miembros del equipo basados en la confianza a las personas con mayor conocimiento, desarrollo de las tareas y un gran interés en realizar estas investigaciones en México. Al reunir muchas personas experimentadas con diversas especialidades, se creó la experiencia interpersonal que dió el resultado antes mencionado. La camaradería inspiró el trabajo intenso y la dedicación profesional de cada individuo a su tarea específica, cada miembro desarrolló un convencimiento personal de su importancia en el proyecto, este es el

ingrediente de tipo social que como "química personal" es un elemento esencial en el desarrollo de equipos efectivos, motivados por sí mismos.

El proceso utilizado para desarrollar este proyecto, está basado en la filosofía de Maser (1994) sobre "Manejo Adaptable de Ecosistemas", donde el autor describe el proceso como diseñado "para el aprendizaje rápido y efectivo por científicos, gerentes, sociedad y políticos, para cambios a corto plazo".

El mismo principio fue empleado al diagnosticar la carga de sedimentos suspendidos en el agua del río, originados por el mal estado de los caminos forestales. La tecnología disponible fue transferida (Burns *et al.*, 1995 y Madrigal-Huendo *et al.*, 1995) y desarrollada rápidamente con entrenamiento de campo en áreas con problemas actuales, por los investigadores mexicanos. También fueron instruídos e involucrados en el empleo de la tecnología los gerentes y propietarios, para lograr así, su apoyo con recursos humanos y facilitar la difusión del conocimiento. El resultado esperado es reducir la cantidad de sedimentos que se van al río, mejorar la calidad del agua y reducir los efectos acumulativos en el sistema acuático.

Probablemente uno de los resultados más importante fue la habilidad de gerentes, propietarios e investigadores mexicanos en reconocer la importancia y el alto valor de los ecosistemas ribereños como componentes del manejo de las cuencas. También se reconoció la capacidad de las áreas ribereñas para la producción sostenible de agua de buena calidad, que en la región es un producto poco frecuente. Además, quedaron claros los efectos acumulativos del pastoreo, extracción de madera y construcción de caminos, como parte importante a controlar en un ecosistema forestal de uso intensivo. El conocimiento desarrollado es crítico para cumplir con las demandas crecientes en México, de una mejor calidad de vida en México.

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La vegetación ribereña de la cuenca El Carrizal, Tapalpa, Jalisco, México

Xavier Madrigal-Sánchez[1], Alvin L. Medina[2], Trinidad Saénz-Reyes[3] y Yolanda Chávez-Huerta[4]

En México, el conocimiento y manejo de la vegetación ribereña es limitado. La importancia de estas áreas como un recurso vital en el manejo de las cuencas no es bien conocido, este es el segundo estudio formal de este tipo de vegetación en México. El manejo de la vegetación ribereña puede influír definitivamente en la calidad y cantidad de agua disponible y en el ciclo hidrológico a través del año en que esta fluye en la cuenca. Con el estudio de la composición florística de la cuenca experimental del arroyo El Carrizal, en la serranía de Tapalpa, Jalisco, se dió inicio a la identificación de la composición de las asociaciones vegetales como un antecedente para entender el ecosistema ribereño.

Los objetivos fueron identificar las especies por estratos y definir las especies ribereñas obligatorias, las facultativas y las ruderales. En aproximadamente 2,500 parcelas se identificaron todas las especies por estrato, se han identificado alrededor de 250 especies, de las cuales 25 son árboles y 30 arbustos. La familia con mayor número de especies es la *Compositae* con 27 especies, le siguen la *Polypodiaceae*, con 10 especies, la *Rosaceae* con 9 especies, la *Gramineae* con 8 especies, la *Labiatae* con 7 especies, la *Leguminosae* y *Rubiaceae* con 5 especies, la *Onagraceae* con 4 y la *Salicaceae* y *Umbelliferae* con 3 especies, también hay otras familias representadas con una sola especie.

Las conclusiones preliminares de este estudio son:

1. El estudio es fundamental y provee las bases para comprender la estructura y función de la vegetación en el ciclo hidrológico;
2. Orienta sobre las especies a utilizar para la conservación y restauración de habitats acuáticos para producir agua de buena calidad y reducir los efectos adversos de inundación y escurrimiento;
3. Provee las bases para la identificación y clasificación del hábitat de la fauna silvestre; y
4. Ayuda en la selección de especies para ser reproducidas en viveros forestales para la recuperación de otros cauces en la región.

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Macroinvertebrados acuáticos de la cuenca del arroyo El Carrizal y su relación con la condición de la cuenca

Alvin L. Medina[1], J. Trinidad Saénz-Reyes[2] y Constantino Orduña-Trejo[2]

Fueron colectados insectos acuáticos durante la época de lluvias en varios sitios de la cuenca del arroyo El Carrizal y se identificaron varias especies. Conociendo las especies, se puede predecir la calidad de agua o hábitat acuático. Los datos mostraron que la calidad en estos sitios es muy variable y que existen problemas en la calidad del agua en algunos de ellos con respecto a las actividades de manejo del bosque o pastizales.

La evaluación preliminar de insectos acuáticos es una herramienta que se utiliza para determinar la calidad de las áreas ribereñas. Los sitios degradados tienen las especies de insectos que son indicadoras de las condiciones que prevalecen. Este trabajo de investigación se complementará con otros estudios en proceso sobre calidad de agua en esta cuenca. Las especies mas tolerantes a las condiciones de sedimentación en la zona ribereña son las siguientes: *Traulodes bicornuta, Helicopsyche borealis, Antocha monticola,* y *Ephemerella inermis.*

Fueron identificadas otras especies que son indicadoras de aguas enriquecidas por materia orgánica a nivel de género, tales como: *Chironomii, Orthocladiinae, Heptagenia* y *Baetis.*

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PONENCIAS VOLUNTARIAS

Aplicacion de sistemas de información geográfica en la evaluacion de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

Malchus B. Baker Jr.[1], Yolanda Chávez-Huerta[2], Alvin L. Medina[3] y Steve Dudley[4]

Resumen.- Se utilizó un sistema de información geográfica (SIG) en la cuenca del arroyo El Carrizal en Jalisco, México, para evaluar, monitorear y analizar las interacciones suelo-agua. En la base de datos del SIG se capturaron 18 estratos de información, incluyendo elevación, drenaje, geología, hidrografía, uso del suelo, cobertura vegetal, suelos e información social. Otros datos como precipitación pluvial, flujo y calidad del agua, están dentro de una base de datos relacional (*Paradox*), que se complementa con el SIG. Como ejemplos de las aplicaciones del SIG se incluyen análisis de erosión potencial, planeación del uso del suelo y modelos de calidad del agua.

INTRODUCCIÓN

El proyecto de manejo y restauración de áreas ribereñas (RARM), se inició en 1993 con la finalidad de evaluar, monitorear y analizar la interacción suelo-agua en la cuenca del arroyo El Carrizal, ubicada en municipio de Tapalpa, México (Medina *et al*., 1995). Para alcanzar estos objetivos fué necesario tener la capacidad de manejar, almacenar y procesar gran cantidad de datos de la cuenca. Debido a que los atributos espaciales de estos datos, que incluyen hidrología, fisiografía, geología, suelos, vegetación, uso del suelo, fauna silvestre e información social, son importantes para entender las funciones y las interacciones que ocurren el ecosistema de la cuenca, se decidió utilizar un SIG para facilitar estas tareas (Aronoff, 1989). Se espera que el desarrollo de este proyecto proporcione las habilidades, el equipo y los programas de cómputo (*hardware y software*), para almacenar y analizar la información de manera más eficiente y económica.

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ÁREA DE ESTUDIO

La cuenca del arroyo El Carrizal, se encuentra en la Sierra de Tapalpa, que es parte del Eje Neovolcánico Transmexicano, en el municipio de Tapalpa, Jalisco (Figura 1). El bosque está compuesto por especies

Figura 1. Localización de la cuenca del arroyo El Carrizal, Municipio de Tapalpa, Jalisco.

de la zona templada, como pinos y encinos (*Pinus* y *Quercus*). El clima es templado subhúmedo. Durante el año hay algunos meses ligeramente cálidos, que normalmemente marcan el inicio de las lluvias de verano. La mayor cantidad de lluvia (79% del total anual) ocurre de junio a octubre (Benavides *et al.*, 1995). La precipitación pluvial media anual es de 901 mm (basada en datos de 51 años de la estación meteorológica de Tapalpa, Jalisco).

La cuenca del arroyo El Carrizal tiene 1,170 Ha, las altitudes extremas se encuentran a 2,100 msnm en la presa El Nogal y a 2,420 msnm en el límite superior de la cuenca (Figura 2). El área forestal ocupa el 71% de la cuenca y se inicia cerca de la cota 2100 msnm (Figura 3).

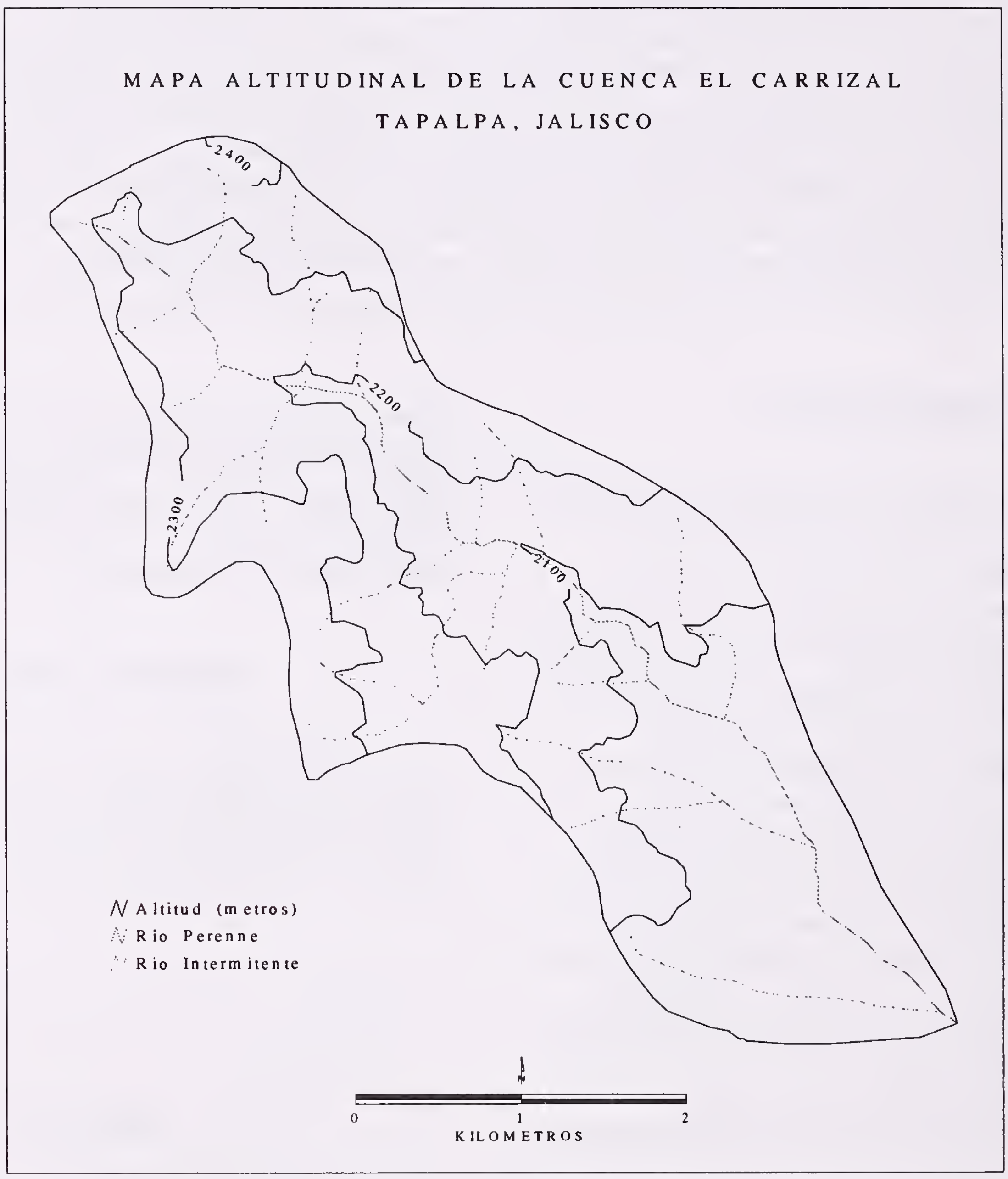

Figura 2. Mapa topográfico de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

Los suelos en esta área corresponden a regosoles éutricos (en el Sistema FAO/UNESCO; Buol *et al.*, 1980), que se formaron sobre material parental de basalto (Figuras 4 y 5).

Hay una estación de aforo a los 2,060 msnm y se utiliza para las mediciones de flujo del arroyo, que provienen de la porción arbolada de la cuenca hidrográfica (Figura 6).

La parte baja de la cuenca (por debajo de la cota 2,100 msnm) no tiene arbolado primario y es usada para pastoreo, producción de forraje o agricultura (Figuras 2 y 3). Aquí los suelos son feozem desarrollados sobre depósitos aluviales y son ampliamente usados para la agricultura; mientras que los suelos de feozem desarrollados sobre material basáltico son utilizados principalmente

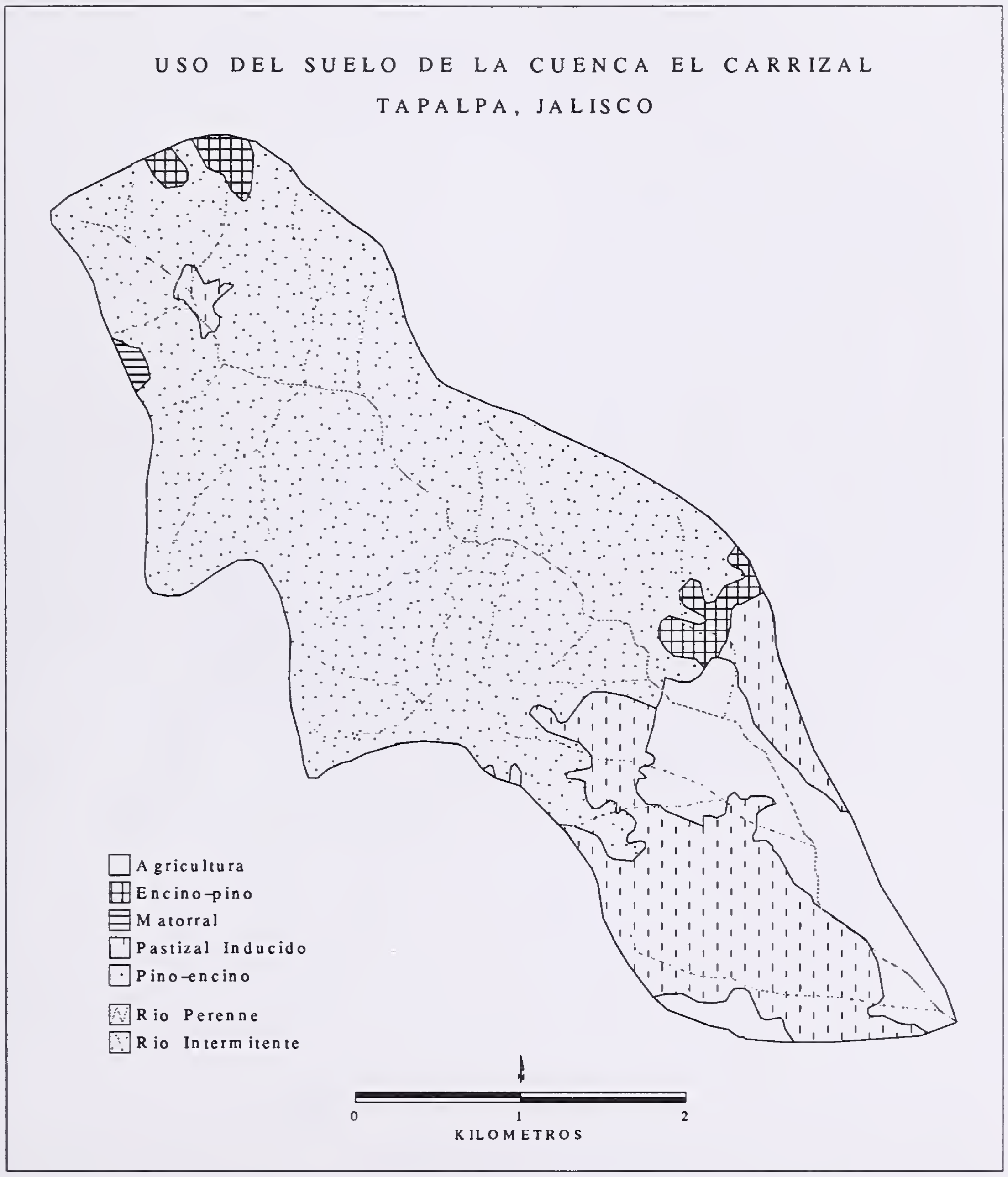

Figura 3. Mapa de uso del suelo en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

para producción de forraje para ganado vacuno y ovejas (Figuras 4 y 5). Gómez-Tagle y Chávez (1986), reportan la presencia de otras unidades de suelo en la región como andosoles húmicos, cambisoles dístricos y luvisoles crómicos.

El sistema de drenaje de la cuenca tiene corrientes, tanto perennes como intermitentes, distribuídas en toda el área (Figuras 2 a la 6). El arroyo principal corre de noroeste a sureste.

La cuenca está ubicada en 9 predios, el mayor de ellos es la propiedad denominada Pegueros (ocupa 20%) y la más pequeña es Las Animas (1%). Los porcentajes de los diferentes usos del suelo varían de un predio a otro (Cuadro 1).

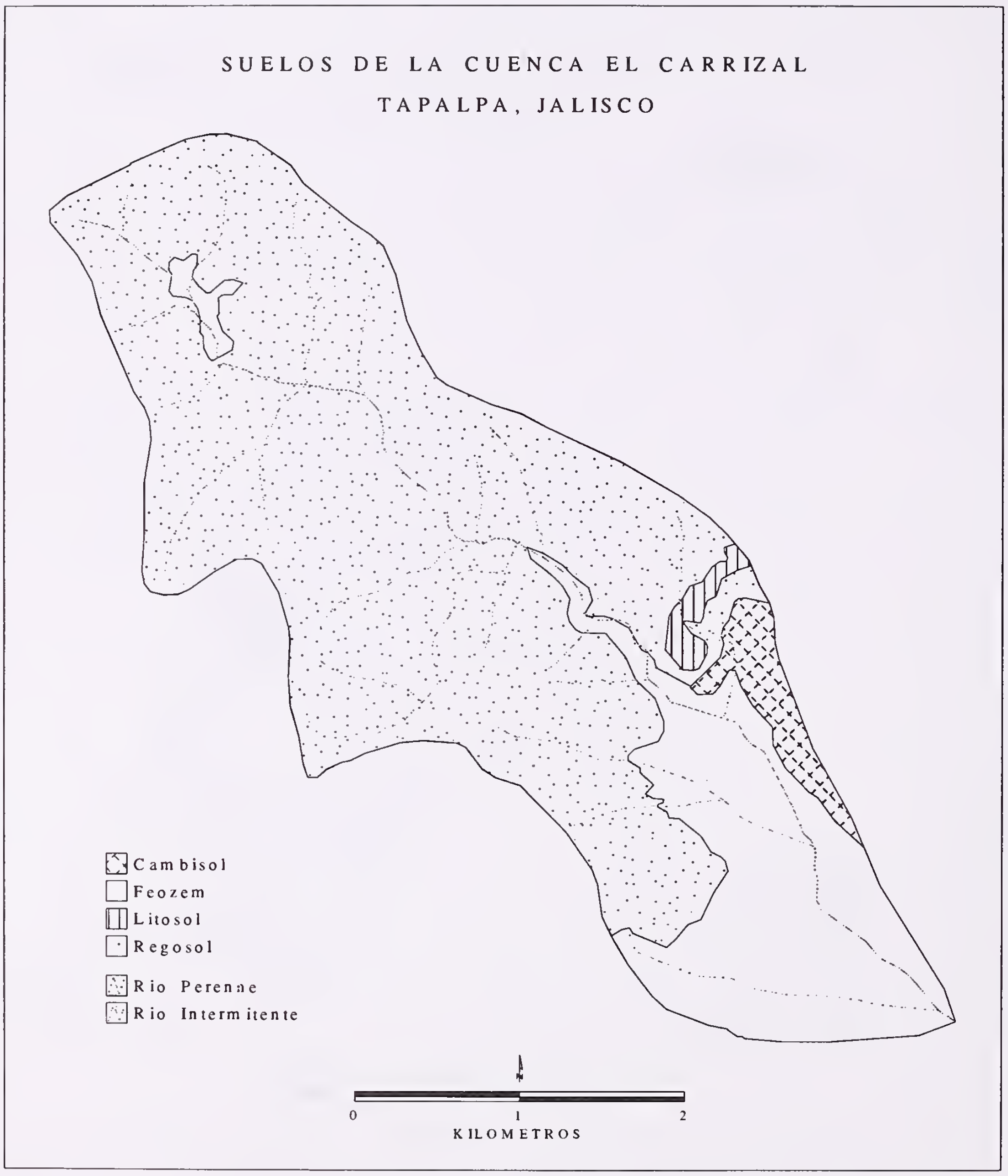

Figura 4. Mapa edafológico de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

MÉTODOS

Se desarrolló una base de datos que permite almacenar información en formato de celdas (*raster*) o en formato vector. Los datos se introducen y analizan utilizando varios paquetes computarizados (*software*), entre los cuales se incluye el sistema ERDAS[5] (Earth Resources Data Analysis System), ILWIS (Integrated Land and Water Information System), LTPlus[5] y PC ARC/INFO[5]. El equipo utilizado (*hardware*) lo constituyen computadoras personales (PC), sin embargo es posible que algunas de las operaciones que se llevan a cabo requieran de un ambiente de estación de

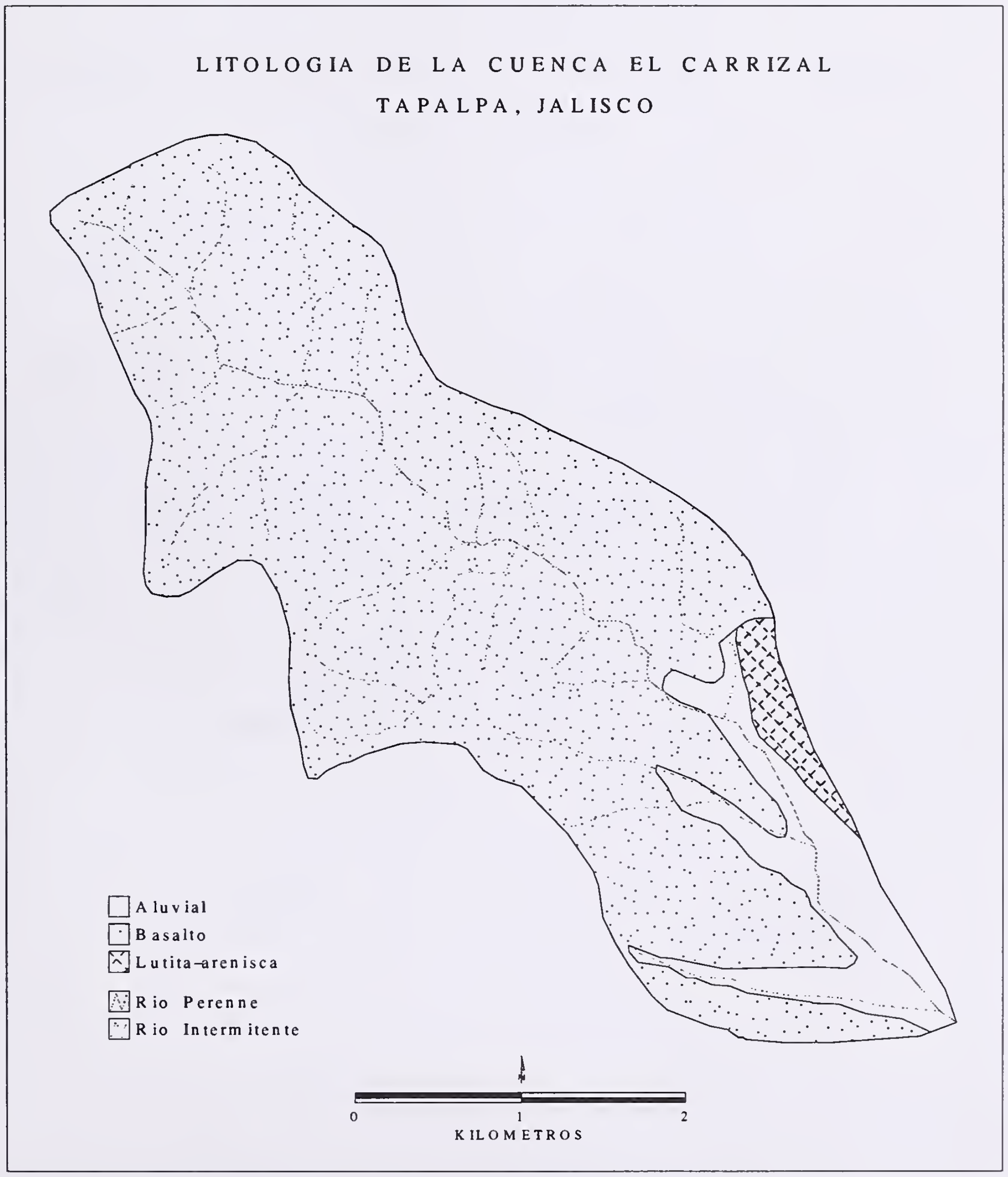

Figura 5. Litología de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

trabajo (*work station*) para una ejecución mas eficiente; si éste es el caso, se utilizará esta información transformándola de versión de PC a estación de trabajo. La intercomunicación de Paradox e Informix (que son sistemas de bases de datos relacionales para PC y estación de trabajo respectivamente) con el SIG es importante, debido a que esto permite que los datos hidrológicos y de calidad del agua, puedan ser colectados diariamente o con mayor frecuencia, si esto es necesario y puedan ser procesados y utilizados fácilmente por el SIG. Cada registro en la base de datos, puede ser relacionado con el mapa usando las coordenadas de la estación de muestreo y por lo tanto, cualquier imágen del área puede ser corregida geográficamente.

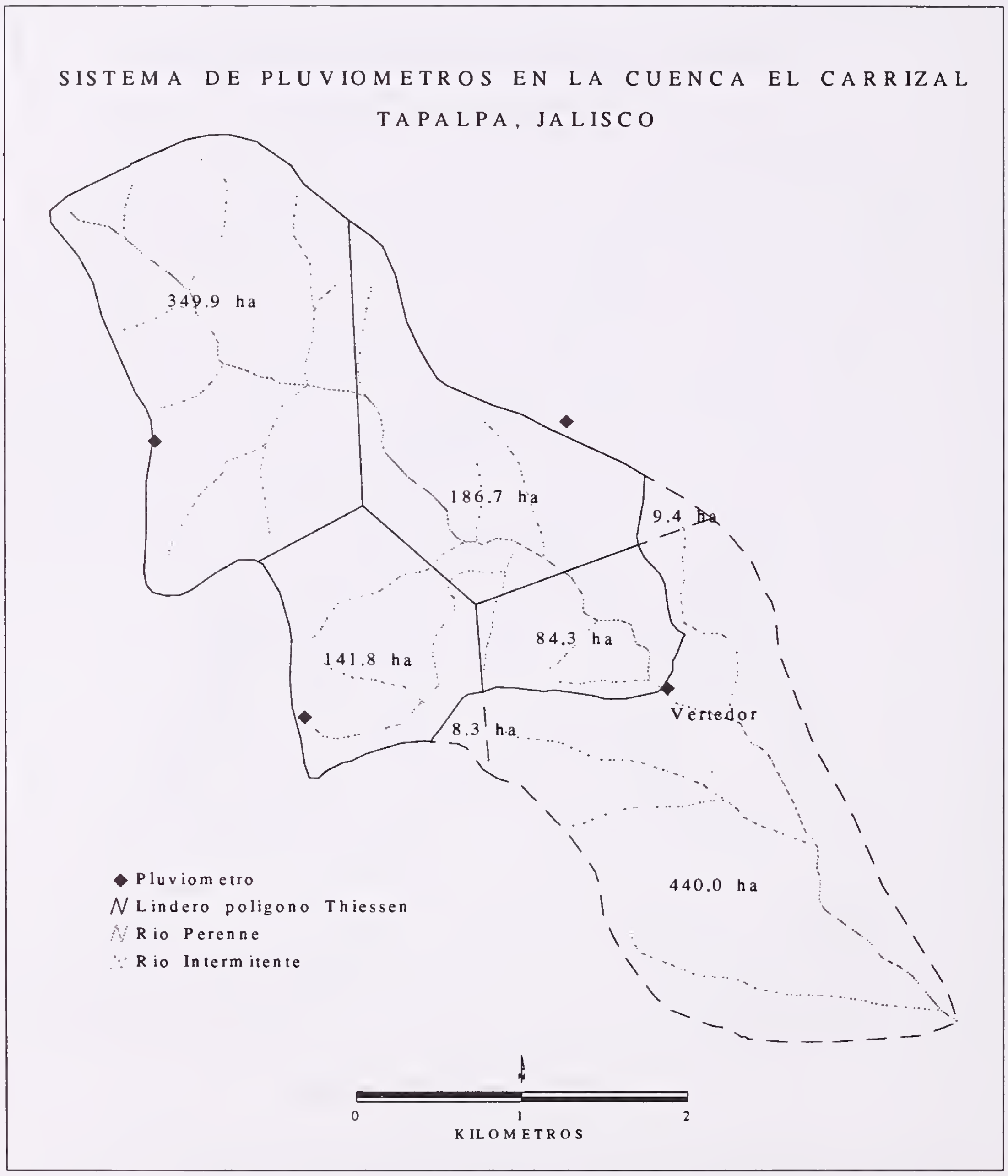

Figura 6. Ubicación de pluviógrafos y medidores de flujo en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

Grupos de datos y cobertura

El primer paso en el desarrollo de la base de datos, fue el de introducir varios tipos de datos en el sistema relacional. En la base Paradox fueron introducidos los datos de calidad del agua, flujo de descarga en canales y precipitación pluvial. La cuenca, los sitios de muestreo, el sistema de drenaje, la geología, los suelos, la vegetación y el uso del suelo, fueron digitalizados de los mapas temáticos escala 1:50,000 (INEGI, 1976) y los linderos prediales se digitalizaron del mapa de propietarios de Tapalpa.

La información sobre precipitación pluvial está siendo colectada por cuatro pluviómetros (Figura 6). Se uso el método de Thiessen para

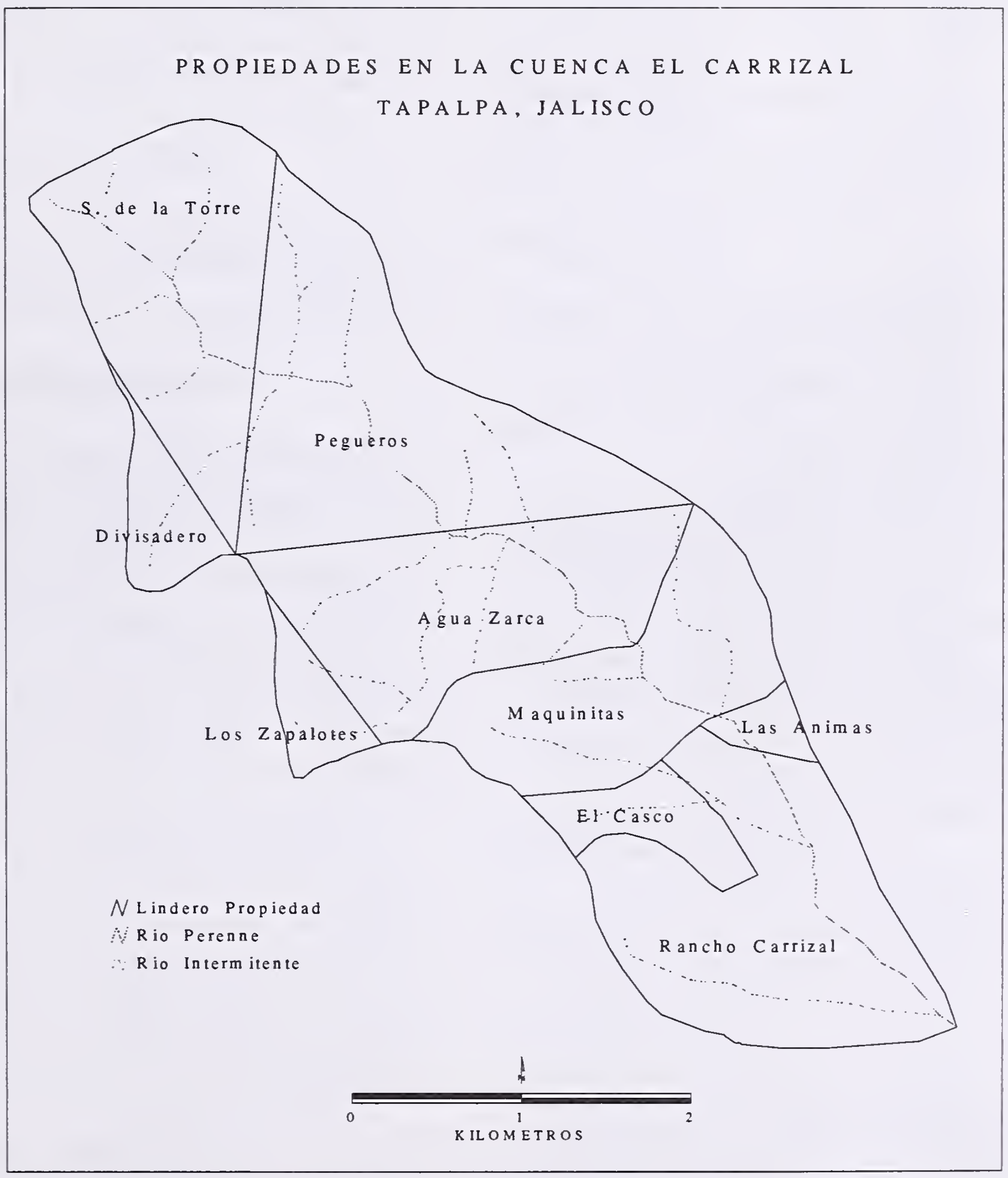

Figura 7. Mapa de predios de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

Cuadro 1. Relación de predios dentro de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

NOMBRE DEL PREDIO	PORCENTAJE	USO DEL SUELO
AGUA ZARCA	16	FORESTAL
EL CASCO	4	25% FORESTAL 75% PASTIZAL
EL DIVISADERO	3	FORESTAL
LAS MAQUINITAS	14	50% FORESTAL, 30% PASTIZAL, 20% AGRÍCOLA
LOS ZAPALOTES	3	FORESTAL
PEGUEROS	22	FORESTAL
RANCHO EL CARRIZAL	20	60% PASTIZAL 40% AGRICOLA
SANTIAGO DE LA TORRE	17	80% FORESTAL 20% PASTIZAL
	100	

obtener el promedio de precipitación de la cuenca (Benavides *et al.*, 1995). El flujo de agua en el arroyo se medide con un vertedor en "V" a 120° y un **"microloger**" (Baker *et al.*, 1995), con capacidad de 2 metros cúbicos por segundo.

El promedio del nivel del agua del arroyo, es almacenado cada cinco minutos y posteriormente es convertido a descarga. Como se mencionó previamente, los datos de precipitación y flujo del arroyo, quedan disponibles para el SIG, usando el programa de intercomunicación Paradox (interfase).

La información de calidad de agua es obtenida mediante un muestreador y analizador de agua automatizado (Medina, *et al.*, 1995). El monitoreo de la calidad del agua se inició en abril de 1994 en tres localidades de la cuenca. La información colectada cada 30 minutos incluye: temperatura del agua, pH, conductividad eléctrica, porcentaje de saturación de oxígeno disuelto (PDO) y sólidos totales disueltos. También hay tres muestreadores automáticos de agua, que son usados para tomar dos muestras por día, las cuales al ser analizadas proporcionan información adicional de la calidad de agua con parámetros como: nitratos, fosfatos, sulfatos, cationes, metales pesados y sedimentos suspendidos.

Además se hace un muestreo periódico en seis localidades de la cuenca, iniciando de la presa hacia la parte alta. Estas muestras también son analizadas en un laboratorio móvil, que cuenta con paquetes de reactivos de tipo comercial y se cuantifican parámetros físicos, químicos y bacteriológicos. El muestreo de macroinvertebrados (Plafkin *et al.*, 1986), se planeó espacialmente para que coincidiera con los sitios de muestreo de calidad del agua. La información de la calidad del agua, queda disponible para su análisis con el SIG, por medio de una interfase de la base de datos relacional.

Capas de información

Los datos actuales están distribuidos en 18 capas de información, estas y los archivos de los atributos asociados se enlistan en el Cuadro 2.

Procesamiento con el SIG

El análisis de la información mediante el SIG puede variar considerablemente. La información en cualquier capa o archivo de atributos puede ser recuperada individualmente y graficada en un mapa o generar una salida en formato estadístico.

Cualquiera de los campos disponibles en la base de datos puede ser accesado y desplegado como texto por varias vías, también es posible hacer un filtrado de la base de datos para seleccionar requerimientos específicos.

Asimismo el desplegado de información estractada de una sola capa y el archivo de atributos correspondiente puede ser realizado frecuentemente. Una de las mejores alternativas de uso del SIG es cuando la información contenida en dos o más capas es manipulada; las Figuras 2 a la 7 son ejemplos del producto de salida.

Analisis futuro

Por medio del uso del SIG se ha facilitado el inventario y caracterización de la cuenca del arroyo El Carrizal. Algunos de los usos futuros posibles del SIG, incluyen el análisis de la calidad del agua, sus caacterísticas físicas y químicas, presencia de problemas específicos en la cuenca y

[5] *El uso de nombres comerciales y compañías es para beneficio del lector; tal uso no constituye endoso o aprobación oficial de ningún servicio o producto por parte del Departamento de Agricultura de los E.U.A. o de la Secretaría de Agricultura y Recursos Hidráulicoc de México, a la exclusión de otros que puede ser adecuados.*

Cuadro 2. Capas de información y archivos de atributos

CAPA DE INFORMACIÓN	ARCHIVO DE ATRIBUTOS
Características culturales	
Límites de propietarios	Nombre del propietario Localización Área
Caminos	Código de la estación Localización Kilómetros Uso Riesgos de erosión Proximidad al canal
Elevación	Valor de la cota
Elevación	Localización
Drenaje de la cuenca	Nombre de la cuenca Localización Área
Geología	Material parental Localización
Sistema de canales	
Perennes	Tipo de canales
Intermitentes	Localización Longitud
Cubierta forestal	Descripción de la clase Localización
Suelos	Nombre del suelo Localización Textura
Precipitación	Código de la estación Localización Coeficiente de Theissen
Descarga de arroyos	Código de la estación Localización
Datos de calidad de agua (Hydrolabs)	Codigo de la estación Localización pH Temperatura Oxígeno disuelto Conductividad Potencial Redox Total de sólidos disueltos
ISCO	Código de la estación Localización Sedimientos suspendidos Nitratos
ISCO (Cont'd.)	Fósforo Aluminio Fierro Potasio Sodio Sulfatos
Muestras de profundidad	Código de la estación Localización Bacteriología Química Física
Macroinvertebrados acuáticos	Código de la estación Localización Especies
Vegetación ribereña (Medina, 1986)	Código de la estación Localización Especies (o taxa) Composición de especies Densidad de especies Cobertura de especies Estructura Clasificación del hábitat
Clasificación del canal (Rosgen, 1994)	Localización Ancho Profundidad Sustrato Pendiente Confinamiento Sinuosidad Descarga Tipo
Inventario de fauna silvestre	Mamíferos Código de la estación Localización Especies Hábitat Especies asociadas Aves Código de la estación Localización Especies Hábitat Especies asociadas

desde luego, la posibilidad de definir a que puedan deberse.

El análisis preliminar de la información indica elevación inusual de la concentración de fierro, acumulación de sedimentos finos en el sistema de canales, presencia de macroinvertebrados acuáticos típicos de condiciones de contaminación, niveles elevados de bacterias coliformes y variaciones del pH en varias sitios de la cuenca.

También es factible correlacionar la pérdida de los nutrientes y sedimentos a partir de las fuentes de origen, particularmente del material geológico parental o del tipo de suelo y los métodos necesarios para reducir la pérdida de suelos.

Actualmente se sabe que la red de caminos es la mayor fuente de sedimentos finos. Al analizar la condición de los caminos y su localización respecto al sistema de arroyos o canales, los distintos tipos de suelos ó los diseños de construcción de los caminos se pueden definir acciones que ayuden a disminuir la fuente de sedimmentos (Burns *et al.*, 1995).

La apariencia física y el carácter de los arroyos es producto del ajuste de los canales, del flujo y los sedimentos y del régimen de producción de sedimentos (Rosgen, 1994). También los datos de la morfología de canales (Espinoza-Arechiga *et al.*, 1995), acoplada con la información de vegetación (Chávez-Huerta *et al.*, 1995), suelos, calidad del agua (Benavides *et al.*, 1995), flora (Madrigal-Sánchez *et al.*, 1995) y los datos de fauna (Orduña-Trejo y Medina, 1995a, 1995b) definirán el estado de sanidad del ecosistema ribereño y darán indicios de como contribuir al mejoramiento de la cuenca.

Los datos de las especies de aves y mamíferos encontrados en la cuenca sirven para obtener la información básica de la diversidad de especies, abundancia y condición del hábitat (Orduña-Trejo y Medina, 1995a, 1995b). Estos datos, junto con otras fuentes de información, conformarán las relaciones de especies animales presentes en la cuenca, la información de localización de los hábitats y la condición de diversas especies. Se intentará identificar especies indicadoras de condiciones específicas del hábitat. Los valores de los datos de la fauna silvestre se complementarán con los de otras fuentes y se tendrá la facilidad de examinar la cuenca en función del potencial de especies respecto a las actividades de manejo o a la existencia de rodales de vegetación. Este tipo de análisis mediante el SIG permite tener una veriedad de vías para examinar los efectos acumulativos sobre el hábitat de las zonas ribereñas (Hemstrom, 1989).

Estas son algunas aplicaciones y análisis que están considerados usando el SIG; sin embargo, conforme se tenga un mayor conocimiento de la cuenca y se introduzcan más datos, se estará en posibilidad de mayores aplicaciones con el SIG y el procesamiento de la información se hará más eficiente.

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Relaciones entre la precipitación pluvial y el escurrimiento en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

Malchus B. Baker, Jr.[1], Juan de Dios Benavides Solorio[2] y Esteban Talavera Zúñiga[2]

Resumen.—Se estudió una cuenca de 789 Ha respecto a su hidrología, particularmente en el aforo, la precipitación pluvial y el escurrimiento, con la finalidad de ayudar en la evaluación y restauración de su ecosistema ribereño. Los resultados indican que los escurrimientos de la temporada de lluvias del año de 1994, se iniciaron un mes después de la primera lluvia de verano y la respuesta del flujo diario de agua fue asociada con cantidades de lluvia mayores de 10 mm. Los máximos flujos diarios fueron de 5.27 mm y 4.79 mm, los que ocurrieron después de la presencia de lluvias de 60 y 35 mm respectivamente. Un total de 81 mm de escurrimiento se produjo de mayo a octubre con una precipitación total en ese período de 957 mm. Los resultados preliminares indican que el flujo proveniente de las lluvias, es básicamente generado por el escurrimiento subsuperficial y según la tendencia tendrá un promedio de alrededor del 10 % de la precipitación total del año.

INTRODUCCIÓN

El conocimiento básico de la hidrología es fundamental en la planeación y manejo de los recursos naturales con fines de sostenibilidad (Brooks *et al.*, 1991). El conocimiento de la hidrología es fundamental para balancear las demandas de agua con los suministros, evitar inundaciones o desbordes y proteger la calidad del agua.

El estudio hidrológico debe estar implícito cuando se elaboren planes de manejo forestal, de los pastizales y de los terrenos agrícolas, ya que el ignorar los efectos de las actividades agropecuarias y forestales sobre las propiedades físicas y químicas del suelo y del agua, puede acelerar los procesos de deterioro de las partes altas y bajas de la cuenca hacia sus arroyos.

Los cambios en la vegetación y en las condiciones del suelo, pueden alterar el escurrimiento, la producción de sedimentos y la calidad del agua, además, pueden afectar la condición de la cuenca y la salud y bienestar de la población humana que vive en el área.

Para tener un flujo aceptable de agua, es necesario proteger todos los cauces y hacer un buen manejo de la cuenca, teniendo especial cuidado en las partes altas de ésta. La información básica respecto a la hidrología de una cuenca, sirve para entender el funcionamiento específico de un arroyo o río (Rosgen, 1994) y el proceso físico de entrada de los escurrimientos, para aplicar posteriormente el mejor manejo que mantenga en condiciones adecuadas los canales. Esta información tendrá influencia finalmente en la vida acuática (Medina *et al.*, 1995b), la fauna

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silvestre (Orduña-Trejo y Medina 1995a; Orduña-Trejo y Medina 1995b), la vegetación (Chávez-Huerta *et al.*,1995; Sánchez *et al.*, 1995), los suelos y las posibilidades de ofrecer recreación en una cuenca y es necesaria para desarrollar mejores pautas para el personal operativo que lleva a cabo los programas de manejo.

El principal objetivo de este estudio es dar a conocer información preliminar obtenida del régimen de precipitación en la cuenca del arrollo El Carrizal y su influencia sobre el escurrimiento.

ÁREA DE ESTUDIO

La cuenca del arrollo El Carrizal se encuentra en el sistema montañoso conocido como la Sierra de Tapalpa, la cual es parte del Eje Volcánico Transversal y se encuentra a 6 Km de la población de Tapalpa, Jalisco (Medina *et al.* 1995).

El bosque es templado, compuesto principalmente por especies de *Pinus* y *Quercus*. Las altitudes en la cuenca van de 2,060 msnm, donde se localiza el vertedor de aforo, a 2,420 msnm en la cúspide (Baker *et al.*, 1995). El clima es templado subhúmedo, siendo mayo el mes más caluroso y el que marca el inicio de la temporada de lluvias. La mayor parte de la precipitación (80%) ocurre durante los meses de junio a octubre (Figura 2). La precipitación media anual, basada en 51 años de datos de precipitación de la estación

Figura 1. Ubicación de Tapalpa, Jalisco, en la República Mexicana.

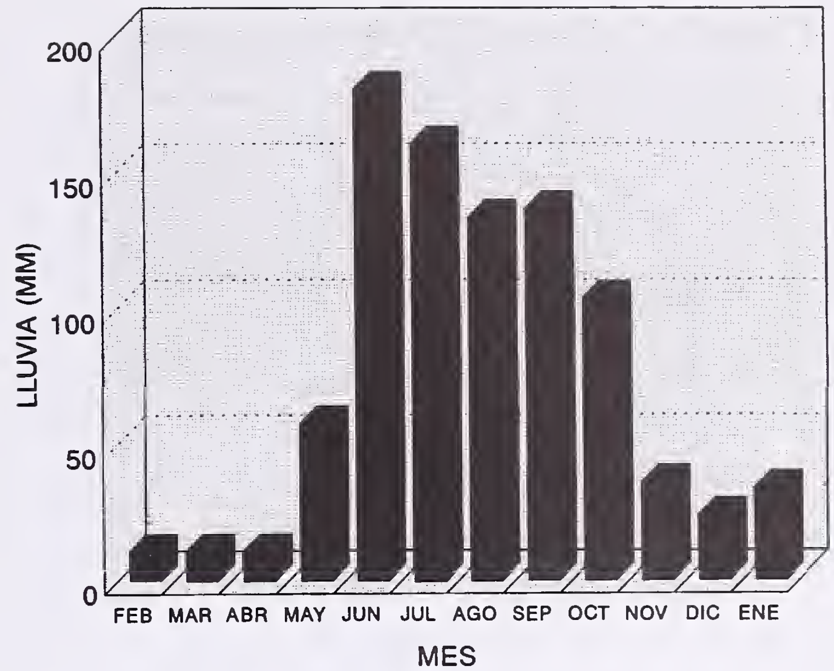

Figura 2. Distribución de la precipitación promedio en el año, con base a 51 años de información.

climatológica de Tapalpa, Jalisco, es de 901 mm (Benavides-Solorio *et al.*, 1995).

La superficie por arriba de la curva de nivel de los 2,100 msnm, está cubierta por bosque y representa el 71% de la cuenca (Figura 3). De acuerdo al sistema FAO/UNESCO (Buol *et al.*, 1980), los suelos del área son regosoles éutricos provenientes de basalto. El vertedor está en la cota de 2,060 msnm y separa esencialmente, los escurrimientos derivados de la parte boscosa, de los del área no boscosa de la cuenca. La superficie de la cuenca por arriba del vertedor comprende 789 Ha.

La porción baja de la cuenca, por abajo de los 2,100 msnm, se utiliza como pastizal o para agricultura (Figura 3), en esta porción los suelos feozem desarrollados sobre depósitos aluviales son usados para la agricultura, mientras que los foezem derivados de basalto, son usados como pastizales para pastoreo. En una pequeña porción de la parte baja de la cuenca hay cambisoles crómicos.

MÉTODOS

Fue instalado un vertedor en forma de "v" con un ángulo de 120° y de un metro de altura, sobre el cauce principal de la cuenca del arroyo El Carrizal, durante el invierno de 1993-1994 (Figura 4). Este

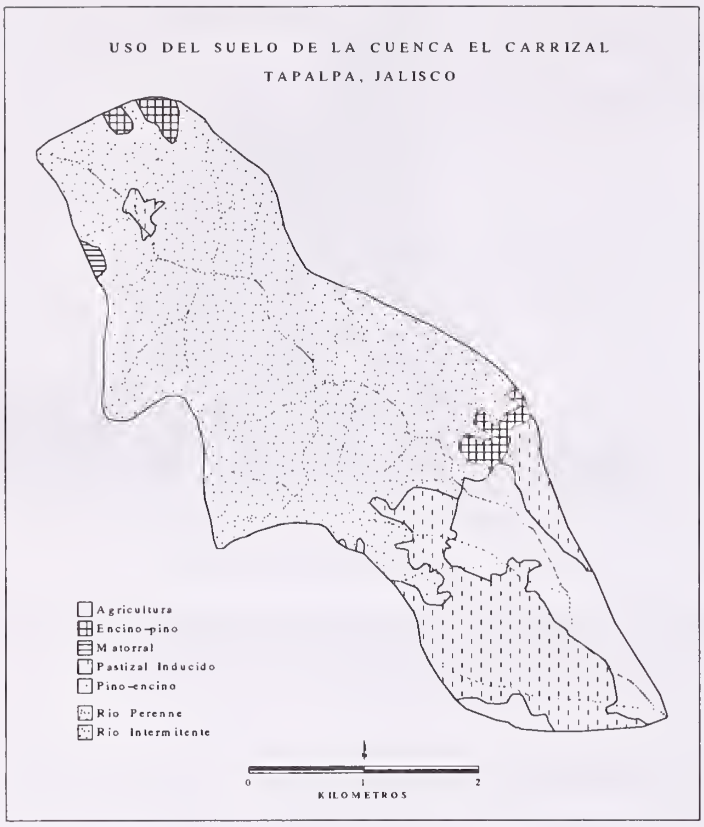

Figura 3. Mapa de uso del suelo en la cuenca de El Carrizal, Tapalpa, Jalisco.

Figura 4. Apreciación de la obra aforadora (vertedor), instalada sobre el cauce del arroyo El Carrizal, Tatalpa, Jalisco.

vertedor tiene la capacidad de medir flujos por arriba de dos metros cúbicos por segundo.

Se usó un micro-registrador computarizado para almacenar el escurrimiento con base al nivel del agua que pasa en ese momento por el vertedor y la cantidad de lluvia proveniente de un pluviómetro en forma de cubo instalado en un mástil. El nivel del agua escurrida, se convierte a descarga o flujo y, posteriormente a unidades superficie de escurrimiento; éstas últimas se comparan con el promedio de unidades superficie de precipitación, el cual se calcula por el método Thiessen, con las cantidades de lluvia totales de los cuatro pluviómetros instalados en la cuenca.

RESULTADOS

El escurrimiento de la cuenca del arroyo El Carrizal, se midió a partir del inicio de la temporada de lluvias de 1994 y las observaciones de campo indican que el flujo del arroyo es perenne antes de llegar a la desviación del cauce que suministra agua al rancho El Carrizal, el cual está localizado por arriba del vertedor. Probablemente en el mes de mayo el escurrimiento alcance su nivel más bajo, debido a la temporada de sequía.

Precipitación

En 1994 el período con mayor factibilidad de lluvia diaria (mayor o igual a 0.05 mm) en la cuenca del arroyo El Carrizal fue de junio a octubre (Figura 2) y ocurrió en 131 días, de 153 posibles, lo que representa el 86% del tiempo (Cuadro 1).

Cuadro 1. Ocurrencia de precipitación diaria en la cuenca del arroyo El Carrizal, de junio a noviembre de 1994 (153 días).

PRECIPITACIÓN DIARIA (mm)	NÚMERO DE DÍAS	PORCENTAJE
> que 0	131	86
> ó = 5	56	37
> ó = 10	32	21
> ó = 20	14	9
> ó = 30	7	5
> ó = 40	2	1

El número de días con precipitación mayor de 5 mm fue de 56 y para 40 mm o más únicamente de 2 días. Los tres días de mayor precipitación en 24 horas fueron el 6 de octubre con 61 mm, el 14 de junio con 40 mm y el 14 de octubre con 25 mm (Figura 5)

La estadística de lluvia mensual para el año de 1994 (Cuadro 2), indica que el patrón fue similar al promedio de los 50 años, excepto para el mes de mayo, el cual tuvo un 30% más que el promedio de 50 años.

Escurrimiento

El escurrimiento en 1994, se elevó un mes después de que iniciara la temporada de lluvias (Figura 5). Durante ese período, cinco tormentas produjeron 15 mm de lluvia en la cuenca. El escurrimiento sobre el vertedor, se inició después de la tormenta del 28 de mayo, la cual produjo un promedio de 24 mm de lluvia sobre la cuenca.

El flujo fue intermitente durante dos semanas y se transformó en continuo después de la tormenta del 10 de junio, de 27 mm de lluvia (Figura 5). Los cambios del flujo diario estuvieron asociados, generalmente, con lluvias mayores a 10 mm.

El concepto de fuente de área variable (variable source area VSAC), sugiere que hay dos mecanismos responsables de la respuesta del flujo en la cuenca: la primera fuente, es el flujo directo por saturación del área del canal, y la segunda se debe al flujo rápido de desalojamiento de agua del subsuelo de las partes altas y que fluye por diferencias de pendiente del terreno (Brooks *et al.*, 1991). El canal y las áreas ribereñas aledañas responden más rápidamente a la precipitación; las zonas de la ribera y las cercanas al canal que tengan suelos poco profundos, pueden saturarse rápidamente durante la lluvia, esta zona saturada se va extendiendo mientras continúa la lluvia.

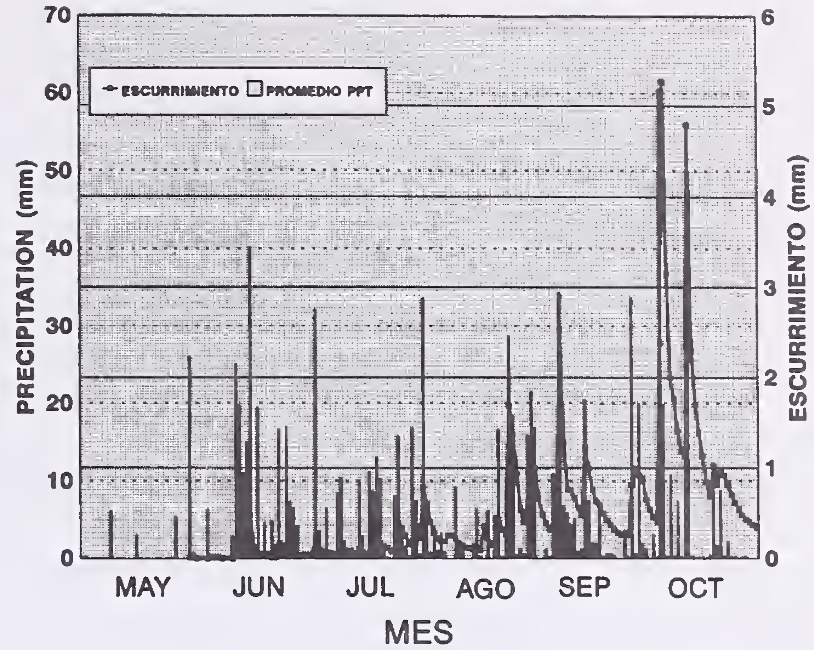

Figura 5. Distribución y comparación de la precipitación y escurrimiento durante el año de 1994, en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

Como el canal del arroyo El Carrizal y la zona de saturación asociada, son relativamente pequeños al inicio de la temporada de lluvias, el aumento del flujo ocurre hasta que la precipitación diaria expande la zona de saturación de la zona ribereña; por ello, durante la primera parte de la temporada de lluvias, la respuesta de flujo está asociada básicamente con precipitaciones diarias mayores de 10 mm; sin embargo, para finales de agosto cuando la temporada de lluvias está bien establecida hay aumento del flujo con lluvias de menor intensidad (Figura 5).

Cuadro 2. Estadística de precipitación mensual sobre la cuenca del arroyo El Carrizal.

MES	DÍAS DE LLUVIA	LLUVIA PROMEDIO EN 50 AÑOS (mm)	LLUVIA EN 1994 (mm)	ESCURRIMIENTO (mm)	EFICIENCIA DEL ESCURRIMIENTO %
MAY	9	58	40	0.02	0.0
JUN	24	181	206	1.99	1.0
JUL	29	161	180	4.41	2.5
AGO	26	134	158	12.67	6.6
SEP	26	137	193	20.16	10.4
OCT	26	104	180	41.75	23.2

Como también hay agua almacenada en los suelos de la cuenca, cuya pendiente está por arriba del canal, el desalojo de ésta contribuye al flujo directo de la zona saturada y de aquí pasa al arroyo (Brooks *et al.*, 1991); por este mecanismo las zonas medias de la pendiente y las áreas bajas de la cuenca pueden producir respuestas de flujo relativamente rápidas, mientras que las zonas cercanas al parteaguas tiene poca influencia en este tipo de flujo, porque la mayor parte del agua infiltrada es almacenada en el suelo y la vía de llegada es más lenta.

La primera respuesta significativa en el escurrimiento (0.61 mm) ocurrió el 14 de junio y se asoció a una precipitación pluvial de 40 mm (Figura 5 y Cuadro 3). El siguiente evento significativo fue el del 1 de agosto, cuando se llegó a 0.78 mm de escurrimiento como respuesta a los 34 mm de lluvia (uno de los 7 eventos que produjeron una precipitación de 30 mm o mayor, Cuadro 1). El primer escurrimiento diario que excedió 1 mm (1.69 mm) fue el 25 de agosto, después de esta fecha el escurrimiento diario se hizo más sensible a la precipitación diaria (Figura 5), aparentemente porque la lluvia superó la capacidad de almacenamiento de agua del suelo de la cuenca (Cuadro 2).

Los flujos máximos diarios de agua fueron de 4.79 y 5.27 mm, ocurridos después de lluvias de 20 y 35 mm respectivamente (Figura 5) La descarga pico de 5.27 mm el día 7 de octubre fue obviamente influida por los 61 mm de lluvia que ocurrieron el día 6 de octubre. La demora en el tiempo de respuesta, proporciona evidencias de que la mayor parte del flujo proviene del escurrimiento subsuperficial. Aunque el flujo superficial también ha sido observado en la cuenca, generalmente se presenta en los caminos y otras pequeñas áreas de la cuenca donde el suelo ha sido compactado o expuesto a bajos niveles de infiltración.

La suma del escurrimiento del verano de 1994 fue de 81 mm, con una lluvia total de 957 mm (Cuadro 2). Estos resultados preliminares junto con las observaciones de campo apoyan la hipótesis de que el flujo en el arroyo El Carrizal es generado básicamente por el movimiento subsuperficial y que es probable que el flujo sea menor del 10% del total de la precipitación anual.

CONCLUSIONES

- Los resultados preliminares del escurrimiento indican que el régimen de flujo de la cuenca del arroyo El Carrizal, es generado principalmente por escurrimiento del subsuelo.
- La zona saturada que contribuye directamente al flujo en el arroyo El Carrizal es relativamente pequeña al inicio de la temporada de lluvias, después de la temporada normal de sequía y requiere cerca de tres meses para llegar al nivel en que el flujo responda directamente a la

Cuadro 3. Estadísticade tormentas cuya precipitación fue mayor o igual a 25 mm en la cuenca del arroyo el carrizal durante el período de mayo a octubre de 1994.

Fecha	Precipitación (sup. mm)	Escurrimiento (sup. mm)	ANTECEDENTES DE PRECIPITACIÓN Primer día (sup. mm)	Segundo día (sup. mm)	Tercer día (sup. mm)
28 may	24.34	0.01	0.00	0.00	0.00
10 jun	27.48	0.08	2.99	2.99	2.99
14 jun	39.87	0.61	15.60	23.60	40.54
02 jul	31.38	0.29	0.34	0.92	1.19
01 ago	33.52	0.78	0.50	7.86	24.62
25 ago	28.70	1.69	4.06	4.19	20.82
08 sep	34.29	2.53	6.60	17.52	17.65
28 sep	33.65	0.81	0.13	3.79	3.79
06 oct	60.58	2.38	0.13	3.17	3.17
07 oct	19.81	5.27	60.58	60.71	63.75
14 oct	34.92	4.79	13.84	13.97	21.21

cantidad de precipitación diaria, aún cuando la precipitación pluvial sea mayor que la media anual.

- El escurrimiento superficial está restringido básicamente a los caminos y a las áreas con suelos desprotegidos, compactos, donde el nivel de infiltración es fácilmente excedido por la lluvia.

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Métodos de bajo costo para el control de sedimentación en caminos

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Resumen.—El objetivo de los proyectos de control de escurrimiento en los caminos, es impedir que los sedimentos lleguen a los ríos; ya que éstos reducen la calidad del agua y hacen más caro el tratamiento del agua para usos humanos. También reducen la productividad del sistema acuático, incluyendo la productividad de los peces. Las prácticas usadas en el control incluyen: cunetas de descarga, trampas de sedimento, bermas, aberturas, pendientes de salida, jorobas y tubos de drenaje. Se pretende el desarrollo de métodos simples. Los tres criterios básicos usados para desarrollar el proceso son: tecnología simple, diseño simple y bajo costo. Todas las prácticas se pueden realizar a mano o con maquinaria, con el uso de los recursos disponibles en el área. El diseño de las obras es hecho en el campo con notas que detallan la práctica aplicada, tamaño, largo, la profundidad, altura, materiales, maquinaria, etc.; el diseño de las obras (tamaño, posición, etc), es ajustado en el campo durante la construcción para asegurar que funcionan como es deseado. Las obras deben realizarse cuando la probabilidad de lluvia es mínima y deben concluirse secciones completas de construcción el mismo día para evitar daños por las lluvias posibles. Se han aplicado estos procesos en algunos lugares en los Bosques Nacionales de Carolina del Norte. No se cuenta con datos muy precisos, pero parece que este proceso ha reducido el nivel de sedimentación de cauces adyacentes hasta en un 75%. Recientemente ocurrió una tormenta con lluvia de 30 cm en 24 horas; estas prácticas sirvieron para disminuir el daño a los caminos y al mismo tiempo protegieron los ríos.

PROBLEMA

En todas las partes del mundo hay muchos kilómetros de caminos de gravilla o superficie natural localizados a lo largo de los cauces. Con cada lluvia, estos caminos depositan muchas toneladas de sedimento en los cauces de los ríos. Una vez que el sedimento está en el río, la calidad del agua se deteriora, algunas veces al punto que no sirve para los usos humanos. El tratamiento para hacer potable el agua es muy costoso. El sedimento puede hacer al agua de mala calidad para los animales y el riego, especialmente el riego por aspersión. También, los peces y otras especies acuáticas mueren si la carga de sedimento es alta, lo que repercute en la producción acuática.

Con la sedimentación, los cauces de los ríos suben, y tienen menos profundidad. Por lo tanto, el volumen de agua que puede pasar en el canal durante la lluvia es menor. Esto causa inundaciones frecuentes en las áreas de poca altura aledañas a los ríos. Además, hay problemas con la sedimentación en los canales y embalses de los sistemas de riego.

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La erosión de la superficie de los caminos también es un problema, la pérdida de los materiales finos, hace la superficie más gruesa, creando problemas para los vehículos que transitan la zona, frecuentemente la erosión inutiliza los caminos.

Muchas veces, la solución a este tipo de problemas de los caminos es únicamente revestir o depositar más gravilla en la superficie o construir un nuevo camino en otro lugar, estos métodos pueden reducir o prevenir la erosión y el flujo de sedimento hacia los ríos, sin embargo, son muy caros y algunas veces difíciles de realizar.

OBJETIVO

Uno de los objetivos de los caminos, debe ser la protección de los recursos que existen aledaños a éstos, como los ríos, la vegetación ribereña, la fauna acuática, la conformación de canales, etc. Con respecto al agua, es muy importante protegerla para el beneficio humano. Es muy costoso y difícil extraer el sedimento del agua cuando está en el cauce. Es mucho más barato y más fácil de controlar el escurrimiento del camino y prevenir la sedimentación antes de llegar al cauce del río. Sin sedimentación, la producción del sistema acuático se protege.

SOLUCIÓN

La solución obvia para terminar la sedimentación contínua es controlar el escurrimiento que lleva el sedimento a los cauces. Simplemente, el principio es controlar el escurrimiento para que no vaya directamente a los cauces de los ríos. El escurrimiento tiene que ser forzado a lugares donde se pueda infiltrar o como mínimo depositarse.

Hay tres criterios básicos que se usan para desarrollar los métodos de control de escurrimiento:

a. Tecnología simple. El método debe de ser fácil de construir y mantener. El entrenamiento para las personas debe ser mínimo, siendo responsables del diseño y la planeación del proyecto.
b. Diseño simple y efectivo. El diseño debe ser hecho principalmente en el campo, por lo tanto el trabajo de la oficina debe ser mínimo.
c. Bajo costo. El método debe usar los recursos disponibles en el área. Las prácticas deben realizarse con mano de obra o con herramientas y máquinas tales como azadón, palas, palas mecánicas, niveladoras, entre otras.

Las prácticas que se usan, son las mismas que las empleadas para el control de la erosión en sitios de conservación de suelos; tales como: nuevas cunetas de descarga, trampas de sedimento, bermas, abertura de bermas naturales, jorobas y tubos de drenaje. Con excepción de las jorobas, todas las prácticas se construyen fuera del camino.

La idea básica, es dispersar el escurrimiento; es decir, tratar de disminuir el volumen del escurrimiento a un mínimo en cualquier punto del camino. Se deben usar todos los lugares disponibles que puedan infiltrar escurrimiento o atrapar sedimento; no es importante si estos lugares son pequeños o grandes, se tienen que usar todos. El procedimiento no pretende concentrar el escurrimiento en un solo sitio, como en algunos otros métodos.

DISEÑO

Debido a la característica de simplicidad la mayoría de los diseños se planean en el campo, por lo tanto hay que tomar buenas notas de campo, detalladas y escenciales, asegurándose que la práctica funcione como fue planeada. La planeación en gabinete está limitada a determinar los recursos necesarios para el proyecto como son: trabajadores, maquinaria, horas de trabajo, herramientas, gravilla, semillas, etc.

La primera etapa de un proyecto es estudiar la sección del camino identificada para controlar el escurrimiento y es necesaria para tener una idea de las condiciones que existen en el camino. Las áreas naturales para el drenaje condicionan el tipo de obras que se pueden construir en el lugar y las medidas que sean necesarias.

La segunda etapa es el diseño en el campo y los sitios estratégicos para trabajar son:

- Lugares donde el agua escurre en ese momento.
- Lugares donde el escurrimiento llega o llegará a un cauce posteriormente.
- Lugares donde el escurrimiento se puede infiltrar.

- lugares donde el sedimento puede ser atrapado.

Es recomendable empezar en el punto más bajo del camino y seguir hacia arriba, de esta manera es más fácil estimar el volumen de escurrimiento que se colecta en cada punto y determinar cuando se necesita una nueva salida de agua. En cada punto crítico, se selecciona una práctica para prevenir que el escurrimiento llegue al cauce, o cuando menos, se deba de sacar al sedimento del escurrimiento.

Cada sitio es marcado físicamente en el terreno, para poder localizarlo al momento de la construcción; además, las notas de campo deben de incluir detalles que van a ser usados en el sitio, tales como tamaño, tipo de construcción, máquinas y materiales necesarios. Lo importante es que se obtenga el resultado esperado.

CONSTRUCCIÓN

El plan de construcción para el control de la erosión y escurrimiento es muy importante. El trabajo deberá localizarse en áreas donde el agua y el sedimento fluyen hacia el cauce. Es importante hacer la construcción cuando la probabilidad de lluvia es mínima. Si es posible, deben iniciarse obras que se terminen el mismo día. También, hay que tomar en cuenta las condiciones climáticas (temperatura y lluvia) que puedan presentarse durante el día.

Debido a que los proyectos de control de escurrimiento están diseñados en el campo, con seguridad deberán hacerse ajustes durante la construcción. Muchas veces la distancia y el escurrimiento calculado entre dos obras requiere ser diferente, o la capacidad de la obra cuando es construida necesita ajustarse; entonces se debe ajustar el sitio de la obra. Por ejemplo, cuando el volumen del escurrimiento es menor al que que se calcula antes de la construcción.

PRÁCTICAS

Las prácticas indicadas pueden hacerse con mano de obra o con maquinaria y su diseño es el mismo, la diferencia es el tiempo necesario para realizar la obra; además es importante construir la obra con los recursos que están disponibles en el área.

Cunetas de Descarga

Las cunetas de descarga son nuevas zanjas de salida creadas a lo largo del camino para reducir y dispersar el escurrimiento más frecuente. Con ellas se reduce el volumen del agua en las zanjas y facilita la infiltración en un área más pequeña. Por ejemplo, en un área entre el camino y un río adyacente. (Figura 1).

El principio es llevar el agua fuera del camino y depositar el sedimento fuera de la cuneta. Por lo tanto, la salida en el fondo debe tener una pendiente bastante fuerte para que el agua no quede en ella. Es ideal que el fondo de la zanja siga hasta el punto que llega a la superficie del terreno natural. Es recomendable sembrar especies vegetales que retengan el suelo a los lados de la nueva cuneta de descarga, pero se debe dejar el fondo sin sembrar para prevenir el depósito de sedimento en la salida. La razón de sembrar es para evitar la velocidad excesiva que produce la erosión en la salida.

Las cunetas de descarga deben ser revisadas con frecuencia para asegurarse que funcionen y que el sedimento no llegue al cauce. Normalmente el mantenimiento de las cunetas se limita a limpiar la entrada y salida de la zanja.

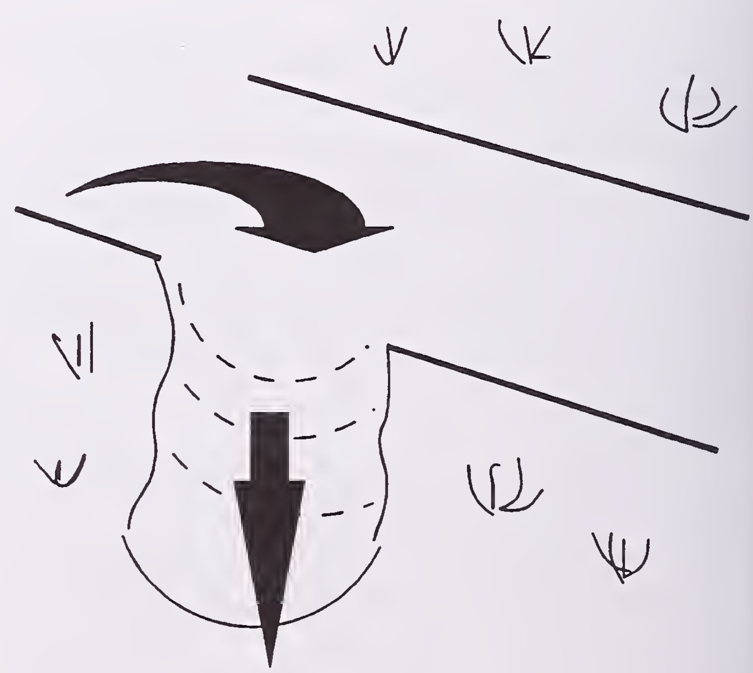

Figura 1. Cunetas de descarga.

Trampas de Sedimento

Las trampas de sedimento son hoyos excavados en el terreno para recoger y mantener el sedimento que fluye en el escurrimiento del camino. Estos hoyos son usados donde el escurrimiento no puede ser infiltrado. Por ejemplo, al final de una zanja muy cercana al cauce del río, o en zanjas que no pueden vaciar antes de llegar al cauce del río.

El tamaño de las trampas es limitado por el espacio disponible y el nivel del agua subterránea, el volumen de la trampa debe de ser bastante grande para que se reduzca la velocidad de la corriente, al punto que el sedimento se deposite. Además, mientras más grande sea el volumen de la trampa, la frecuencia de limpieza y el costo son más bajos; puede disponerse del suelo excavado, siempre que no llegue al cauce del río, es recomendable limpiar las trampas cuando se llenen de sedimento en un 50% de su capacidad (Figura 2).

Bermas

Las bermas son terraplenes o diques de tierra al lado del camino para mantener el escurrimiento en el mismo, son usadas donde no hay espacio entre el cauce y el camino para dispersar la corriente o construir una trampa. Estos son lugares donde el escurrimiento va directamente al cauce a lo largo de una gran distancia. El principio es que el escurrimiento sea forzado a lo largo del dique hacia una área de filtración o una trampa, estos terraplenes o diques funcionan igual que los diques que se forman naturalmente a los lados de los caminos.

Las bermas pueden ser hechas de gravilla o suelo del mismo camino o material nuevo llevado al sitio. Deben ser bastante altas para evitar que la corriente prevista las rebase y no más largas de lo necesario para llegar a un área de infiltración. Si la berma es larga puede necesitar gravilla gruesa para protejer el camino contra la erosión. Deben sembrarse especies vegetales y formar un colchón orgánico inmediátamente después de la construcción para prevenir la sedimentación del cauce justamente al lado de la berma.

Se requieren revisiones frecuentes para asegurar que este funcionando. También, es importante que el mantenimiento del camino no destruya la berma (Figura 3).

Figura 2. Trampa de sedimento.

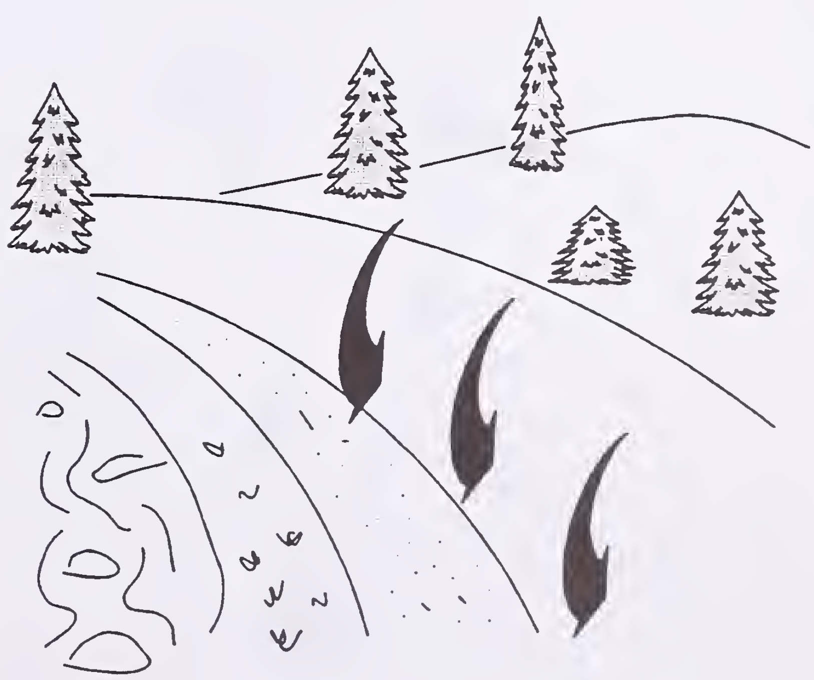

Figura 3. Bermas.

Aberturas

Las aberturas son salidas cortadas en las bermas naturales para permitir el escurrimiento de la superficie del camino hacia la tierra adyacente. Las aberturas son cortadas o hechas en las bermas en cualquier lugar donde haya un área de filtración; muchas veces las aberturas son usadas en las pendientes de salida hechas en el camino (Figura 4).

No deben sembrarse especies vegetales de cobertura ni colocar colchones orgánicos en las aberturas, por que es importante que el escurrimiento no deposite sedimento en la berma. La abertura debe observarse frecuentemente para asegurar el buen funcionamiento y que no esté bloqueada con una nueva berma natural.

Pendientes de Salida

Las pendientes de salida son secciones de la superficie del camino construidas con una inclinación hacia el lado del mismo para que el movimiento del agua sea hacia afuera de su superficie. Son usadas donde la superficie del camino es plana o nivelada y el agua corre a lo largo de él. Esta situación es común en caminos de poco mantenimiento o caminos angostos donde los vehículos transitan en el centro del mismo. Muchas veces las pendientes de salida son usadas junto con las aberturas (Figura 5).

Es mejor y más facil construir las pendientes de salida con maquinaria, pero pueden hacerse con mano de obra, lo que requerirá más tiempo. La extensión e inclinación de la pendiente depende del tipo y velocidad de los vehículos que transitan el camino; la inclinación debe ser bastante fuerte para forzar el agua hacia afuera, pero que no ponga en peligro a los vehículos al pasar por el sitio. La pendiente puede ser en una parte del ancho del camino o en el ancho total.

Las pendientes de salida se deben revisar frecuentemente para asegurarse que no han desaparecido, ni que se haya formado una berma natural.

Figura 4. Abertura

Figura 5. Pendientes de salida.

Jorobas

Las jorobas son secciones del camino que son elevadas a una pendiente positiva para causar que el escurrimiento se salga del camino. las jorobas son usadas cuando el volumen y velocidad del escurrimiento causan erosión de la superficie del camino. Normalmente, las pendientes de salida y aberturas son construidas un poco arriba de las jorobas, para asegurar que ni el agua que queda ni el sedimento, se depositen en el mismo camino (Figura 6).

Las jorobas son hechas con material traido de otro lugar o con material de la superficie que existe en el camino. Es muy importante que la joroba sea dura, hecha con material fuerte, de lo contrario serán fácilmente destruidas por los vehículos en poco tiempo, sobre todo cuando el camino está mojado, o si los vehículos son pesados. Si la joroba es construida con material del suelo debe depositarse gravilla gruesa en la superficie.

Las jorobas no deben ser abruptas tal como reductores de velocidad, hay que construirlas bastante largas para que los vehículos puedan transitar sin disminuir su velocidad. Las jorobas se construyen en forma perpendicular al camino para que las ruedas del vehículo suban la joroba al mismo tiempo; si no es perpendicular, los vehículos pueden ladearse y crear problemas mecánicos. Hay que observar las jorobas frecuentemente para asegurarse que tienen la suficiente altura para desviar el escurrimiento.

Tubos de Drenaje

Son tubos nuevos que se instalan para pasar el agua de la zanja de un lado a otro, donde se pueda infiltrar o captar en una trampa de sedimento. Son usados para minimizar el volumen de agua en una zanja que fluye directamente a un cauce. También se utilizan para reducir el agua que queda en la zanja a un volumen que se pueda captar en una trampa de sedimento o área de filtraje. El costo de los tubos de drenaje es elevado, por esta razón solamente se usan cuando otra combinación de prácticas no es aplicable (Figura 7).

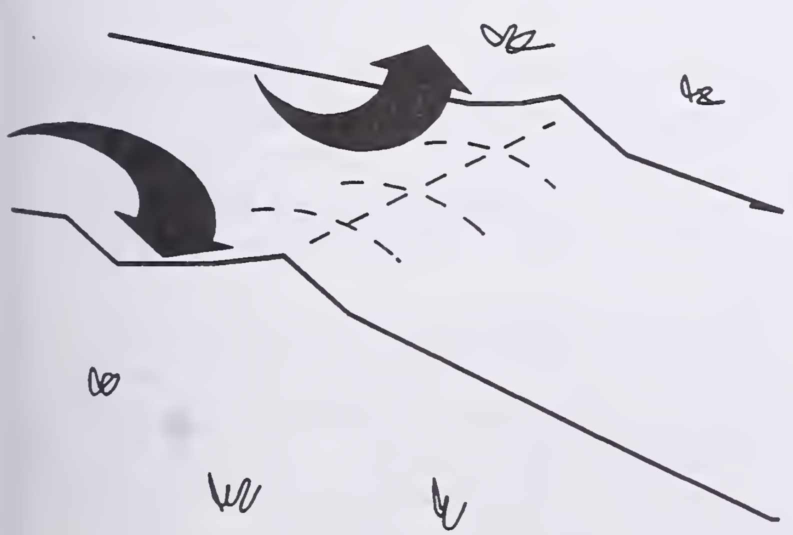

Figura 6. Joroba.

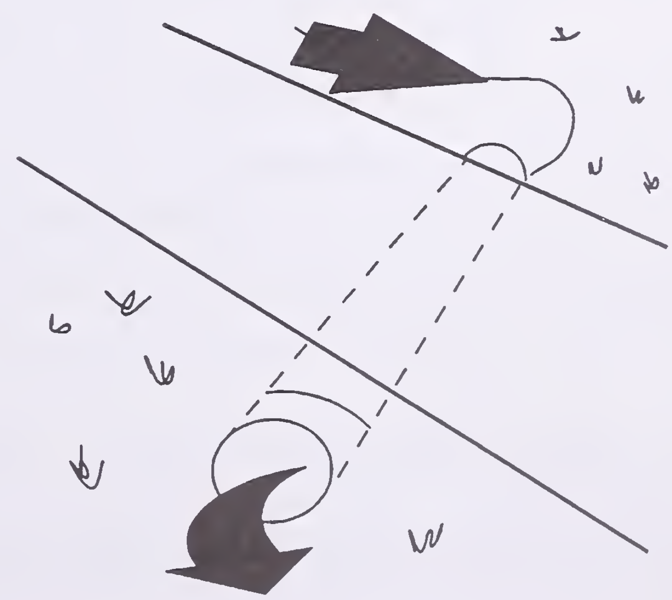

Figura 7. Tubo de salida.

Caracterización preliminar de las asociaciones de vegetación ribereña de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

Yolanda Chavez-Huerta[1], Alvin L. Medina[2], Xavier Madrigal-Sanchez[3] y Trinidad Saenz-Reyes[1]

Resumen.—El objetivo principal de este trabajo, fue el de identificar y caracterizar a las asociaciones vegetales del ecosistema ribereño que se encuentra en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

Con el método de conglomerado de sitios de muestreo de Daubenmiere (1959), modificado por Medina (1986), se muestrearon 27 sitios. Del análisis de la información recabada en los conglomerados, se identificaron ocho tipos de asociaciones vegetales: 1) *Alnus arguta-Cornus excelsa-Salix oxylepis*; 2) *Alnus arguta -Cornus excelsa - Salix bonplandiana-Salix oxylepis*; 3) *Prunus - Salix oxylepis - Rhamnus mucronata*; 4) *Salix bonplandiana - Cornus excelsa-Salix oxylepis-Rhamnus mucronata*; 5) *Ilex tolucana*; 6) *Rhamnus mucronata-Phoebe arsenei*; 7) *Prunus brachybotrya-Rhamnus mucronata*; y 8) *Alnus arguta-Prunus-Fraxinus uhdei*.

Se propone utilizar la información obtenida para: 1) Aumentar el conocimiento de la estructura y composición de las asociaciones vegetales; 2) Establecer puntos de referencia para comparar composición, especies, etc. en estudios de la vegetación ribereña ulteriores; 3) Proporcionar información básica esencial para el desarrollo de planes de manejo de cuencas, 4) Obtener elementos para definir los tipos de hábitat críticos para la fauna silvestre; y 5) Crear un modelo para comparar las condiciones de sanidad de otras cuencas de la región.

INTRODUCCIÓN

El conocimiento de la composición estructural de la vegetación en los ecosistemas ribereños, tiene interés especial para quienes manejan los recursos naturales, debido a que puede proporcionar información a corto y mediano plazos sobre los efectos acumulativos de algunos factores naturales (*v.gr.* geología y clima) y de los cambios inducidos por el hombre a través de prácticas de manejo forestal y de ganadería (*v.gr.* aprovechamientos maderables, caminos y pastoreo) (Brown *et al*, 1978).

En Estados Unidos de América (EUA), los ecosistemas ribereños son reconocidos como un recurso natural de valor inestimable (Johnson y Jones, 1978; Warner y Hendrix, 1984). La condición de estos ecosistemas ha recibido mucha atención (Johnson y McCormick, 1978), pero aún falta mucho por estudiar acerca de su estructura y función, especialmente en términos de sostenibilidad y manejo de los ecosistemas.

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La vegetación de las áreas ribereñas ha sido poco estudiada en México. Quizás el único trabajo publicado es el de Solis-Garza *et al* (1993), en el cual se describe la estructura y clasificación de algunos hábitats ribereños del noroeste de México. En el suroeste de EUA, hay varios estudios de clasificación de la vegetación ribereña, entre ellos los de Medina (1986) y Szaro (1989).

El objetivo de este estudio es hacer una clasificación preliminar de las asociaciones vegetales ribereñas, usando métodos cuantitativos, de la cuenca del arroyo El Carrizal, en el municipio de Tapalpa, Jalisco.

DESCRIPCION DEL AREA DE ESTUDIO

El Carrizal es una pequeña cuenca de 1170 Ha, cubierta con bosque de pino-encino en su mayor parte, ubicada seis Kilómetros al suroeste de la población de Tapalpa, en la Sierra de Tapalpa, estado de Jalisco, México (Figura 1).

La parte más baja a 2,010 msnm de altitud, es el punto en el cual el arroyo El Carrizal desemboca en la presa El Nogal (que almacena 18 millones de metros cubicos) y el sitio más alto se encuentra a 2,420 msnm.

El clima es templado subhúmedo (García, 1988), con precipitación media anual de 903 mm, con rango de 548 mm a 1,549 mm; el 79 % de la lluvia (717 mm) se presenta entre junio y octubre (Benavides *et al*, 1995). El promedio de precipitación pluvial mensual de la estación seca (febrero-abril) es de 11 mm.

Figura 1. Ubicación de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

Los suelos del área (Gómez-Tagle y Chávez, 1986) son regosol éutrico, regosol dístrico, andosol húmico, andosol ócrico, luvisol crómico, cambisol dístrico y litosol éutrico en las partes arboladas y feozem háplico en las zonas más bajas.

La vegetación dominante en el área corresponde al bosque templado de pino, con *Pinus michoacana* Martínez, *P. oocarpa* Schiede, *P. leiophylla* Schl. *et* Cham., *P. douglasiana* Martínez y *P. pseudostrobus* Lindl. Hay también algunos rodales de pino-encino (*Pinus/Quercus*), en ellos hay varias especies y los mejores rodales de pino se encuentran de la parte media de la pendiente hacia arriba. Hay algunos subrodales intercalados con mezcla de *Crataegus y Quercus*, que se han extendido por la cuenca como resultado de los aclareos y de las actividades de extracción de madera (Benavides, 1987).

Sin embargo, a lo largo del cauce del arroyo donde se realizó el muestreo, la vegetación dominante corresponde al bosque mesófilo de montaña, con especies de árboles, arbustos, herbáceas y enredaderas leñosas. Algunas de las especies arbóreas son de los géneros *Alnus, Ilex, Phoebe y Prunus* (Madrigal-Sánchez *et al*, 1995).

Desde hace mucho tiempo y en la actualidad, las actividades en la cuenca incluyen el pastoreo y el aprovechamiento de la madera. Aparentemente el ganado pastorea en la región de Tapalpa desde finales del siglo XVI. Hay evidencias de asentamientos humanos en la cuenca, identificados por la presencia de plantas de ornato, fragmentos de vasijas de barro, un aserradero abandonado, una fundición y algunos puentes de piedra. Hay una mina de piedra a cielo abierto, cuyo producto se usa como material de construcción y como balastro para las calles de la población y para los caminos usados en la extracción de madera.

No hay un registro de los incendios forestales pero se sabe que han ocurrido dos de gran intensidad en el presente siglo, el último de los cuales ocurrió hace aproximadamente 40 años. Los pequeños incendios (de menos de 1 Ha) de origen indeterminado, se presentan ocasionalmente, pero hay vigilancia para combatirlos. El mayor riesgo

potencial de impacto negativo, lo constituye el flujo excesivo de paseantes, asociado al desarrollo turístico y de áreas de recreación.

MÉTODOS

El muestreo de la vegetación se hizo en la primavera y el verano de 1994. Los sitios de muestreo se ubicaron al azar dentro de las diferentes asociaciones vegetales previamente identificadas en recorridos de campo.

Para cuantificar la presencia y la cobertura de las especies, se utilizó el método de conglomerados de muestra de Daubenmiere (1959), adaptado por Medina (1986), muestreándose 27 sitios de 10 x 20 m; dentro de éstos, se midieron 40 parcelas de 0.1 m^2 (16 x 62.5 cm), dispuestas a equidistancias de un metro a ambos lados del canal del arroyo y a 37.5 cm de distancia de la orilla.

Para el muestreo de especies herbáceas se extendió la parcela de muestreo 25 cm dentro del canal, para evaluar las especies acuáticas. También se cuantificó el porcentaje de suelo sin cobertura vegetal.

El estrato arbustivo se estudió en 40 parcelas (20 a cada lado del arroyo) de 1 m^2 cada una, en las cuales 50 cm quedaron hacia el agua y 50 cm en la orilla del arroyo. Para el estrato arbóreo se muestrearon 10 parcelas de 20 m2 (4 x 5 m). Todas las especies leñosas se cuantificaron por clases diamétricas.

La identificación de las especies se hizo siguiendo las claves de Standley (1926), Rzedowski y Rzedowski (1979), Rzedowski (1985) y McVaugh (1983, 1993).

Los grupos de especies del estrato dominante están separados por un guión (-) y las especies de los otros estratos por una diagonal (/). Todos los sitios se marcaron de manera permanente en el campo, para muestreos posteriores.

La sumatoria de los datos por especie y por sitio, se empleó para calcular la densidad, frecuencia y constancia por rodal, para estandarizar de esta manera la matríz de datos (Romesburg, 1984). Con estos parámetros se obtuvo un índice de valor de importancia, que fue usado en el análisis de conglomerado (*cluster*); en la prueba aglomerativa se utilizó el paquete estadístico SAS (1988), para identificar la agrupación de sitios. La distancia Euclidiana representa el índice de diversidad, el cual se utilizó en forma conjunta con el índice estadístico de Ward (1963). Las especies facultativas fueron segregadas del análisis, debido a que el objetivo fué identificar las asociaciones vegetales ribereñas de especies obligadas (Stephenson y Cook, 1980).

RESULTADOS PRELIMINARES

En todos los sitios se identificaron las especies características del bosque mesófilo de montaña, mediante el análisis de agrupación, formándose ocho grupos de vegetación, considerados a nivel de asociaciones (Figura 2). Las unidades de la escala del eje vertical corresponden a la distancia Euclidiana y representan los grados de disimilitud entre los grupos mayores de las especies. Mediante una apreciación subjetiva derivada del conocimiento de campo, se decidió utilizar 3.5 unidades como el nivel de definición de los grupos.

Las asociaciones vegetales identificadas son los siguientes:

- Grupo 1: *Alnus arguta/Cornus excelsa/Salix oxylepis;*
- Grupo 2: *Alnus arguta /Cornus excelsa / Salix bonplandiana-Salix oxylepis;*
- Grupo 3: *Prunus / Salix oxylepis / Rhamnus mucronata;*
- Grupo 4: *Salix bonplandiana / Cornus excelsa / Salix oxylepis / Rhamnus mucronata;*
- Grupo 5: *Ilex tolucana;*
- Grupo 6: *Rhamnus mucronata / Phoebe arsenei;*
- Grupo 7: *Prunus brachybotrya/Rhamnus mucronata*; y
- Grupo 8: *Alnus arguta/Prunus/Fraxinus uhdei.*

Estructuralmente, la vegetación ribereña está compuesta por varios estratos con especies leñosas y plantas herbáceas. En el estrato superior, los árboles de *Alnus*, constituyen la especie obligada más conspicua con *Pinus michoacana* como codominante, que es la especie facultativa más

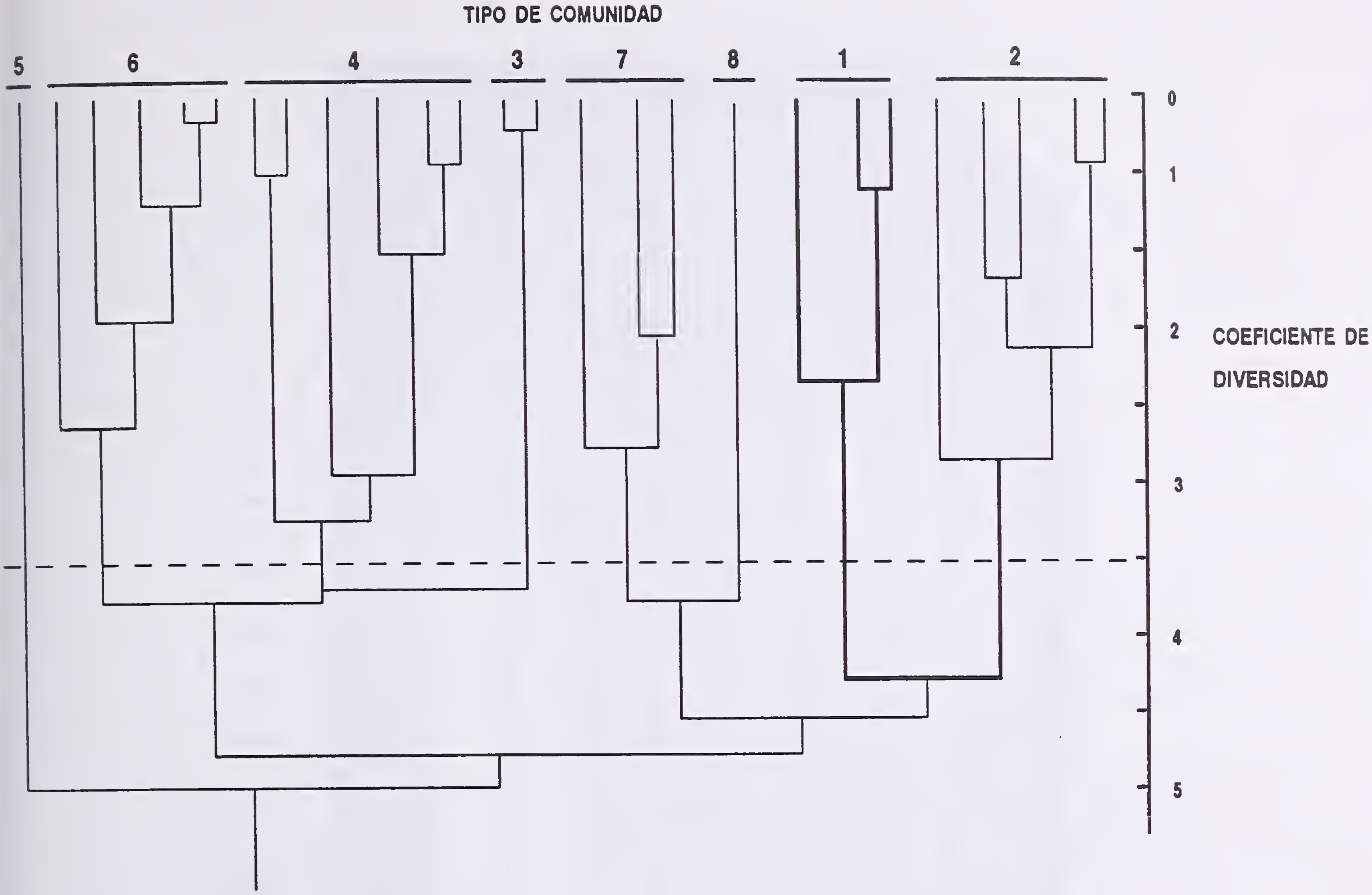

Figura 2. Análisis de la agrupación jerárquica de las comunidades vegetales ribereñas del arroyo El Carrizal, Tapalpa, Jalisco.

frecuente. En el siguiente estrato hay otras especies de los géneros *Fraxinus, Phoebe, Rhamnus, Salix* e *Ilex* que son codominantes, siendo *Ilex* y *Phoebe* las más frecuentes. El estrato inferior comprende las especies dominantes *Cornus excelsa, Prunus* sp. y algunos individuos de *Salix. Crataegus pubescens* (Sinónimo *Crataegus mexicana),* conocida comunmente como tejocote o manzanilla es muy abundante en este estrato (Figura 2).

La distribución general del tejocote en la cuenca es amplia, tanto en el parteaguas como en las zonas ribereñas o en los rodales donde ha habido aprovechamiento del bosque de pino-encino. Esta planta es considerada como indeseable por algunos, ya que estiman que provoca demasiada sombra y compite con los pinos por espacio, agua y nutrientes.

Las principales especies arbustivas pertenecen a los géneros *Vaccinium, Senecio, Salix, Rubus, Baccharis* y *Coriaria*; las zarzamoras (*Rubus spp.)* son abundantes en la ribera y en la parte media y alta de la cuenca. Hay varias especies trepadoras en los árboles bajos y en los arbustos, algunas son tóxicas como la bembericua (*Rhus radicans*), otras especies de *Rhus* ascienden incluso sobre los árboles adultos. Algunas especies herbáceas de los géneros *Carex* y *Juncus,* parecen estar ausentes debido al pastoreo continuo.

La densidad relativa de los árboles y arbustos obligados y facultativos es variable. *Rhamnus*

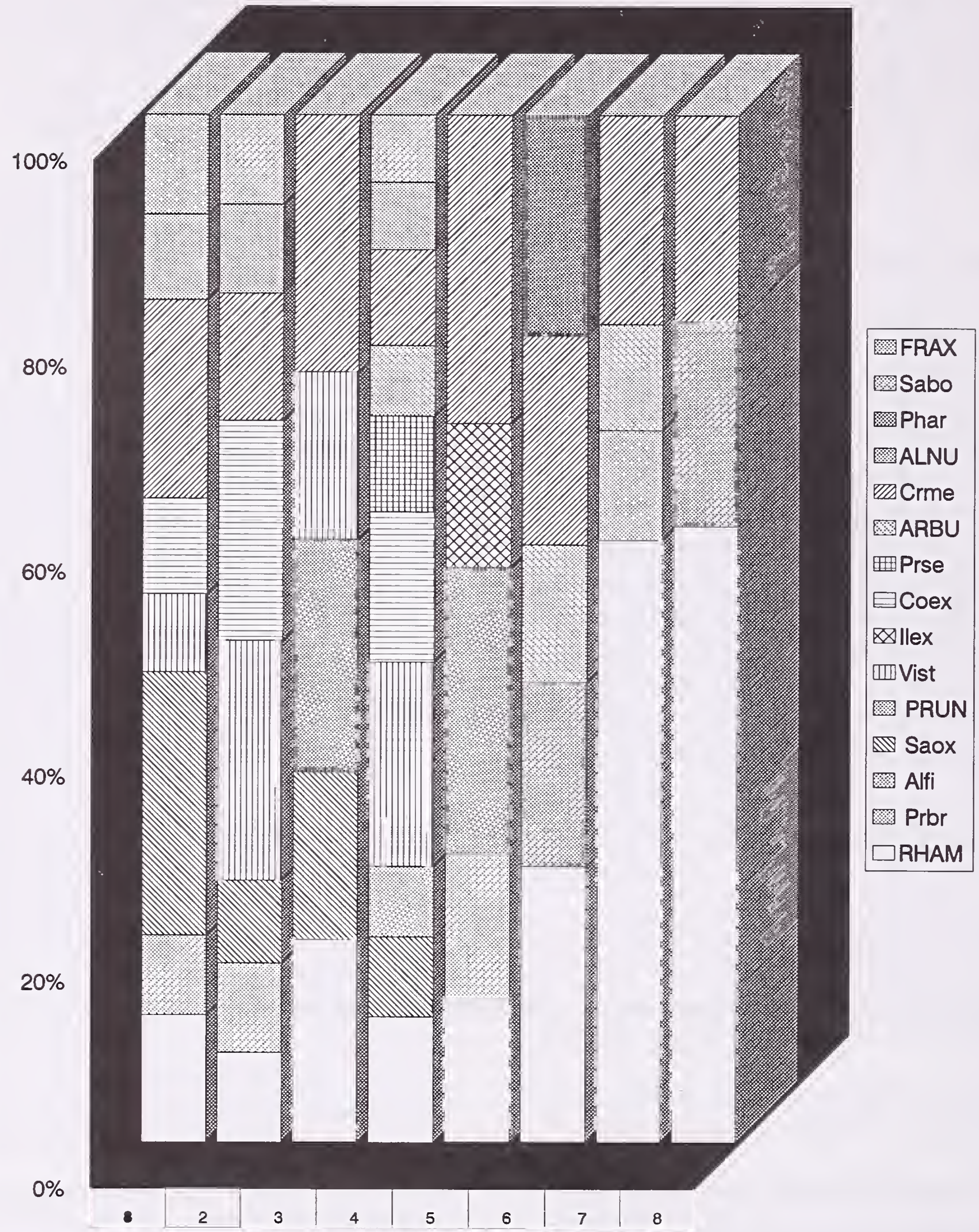

Figura 3. Densidad relativa de árboles por especie y por grupo. FRAX = *Fraxinus* sp., Sabo = *Salix bonplandiana*, Phar = *Phoebe arsenei*, ALNU = *Alnus* spp., Crme = *Crataegus pubescens*, ARBU = *Arbutus* spp., Prse = *Prunus serotina*, Coex = *Cornus excelsa*, Ilex = *Ilex* spp., Vist = *Viburnum stellatum*, PRUN = *Prunus* spp., Saox = *Salix oxylepis*, Alfi = *Alnus firmifolia*, Prbr = *Prunus brachybotrya*, RHAM = *Ramnus mucronata*.

ocupa a *grosso modo* del 10 al 20 % y del 25 al 50 % de la densidad relativa de los árboles en los grupos del 1 al 5 y del 6 al 8 respectivamente; *Crataegus pubescens* fué otra de las especies que estuvieron presentes en todos los grupos, con rango de densidad relativa entre 15 y 30%. Los otros dos componentes mayoritarios fueron *Prunus* (incluye a *P. brachybotrya* y *P. serotina* ssp. *capuli) y Cornus excelsa;* estas especies dominan en el estrato medio o grupo de árboles bajos (4-10 m). La densidad total del arbolado por hectárea varía de 60 a 110, para los ocho grupos, con una media de 75 árboles/Ha (Figura 3).

DISCUSIÓN Y CONCLUSIONES

Los resultados de esta clasificación son preliminares, pero servirán de base para continuar con el muestreo proporcional en cada asociación, para definir de manera más precisa las asociaciones y comunidades. Debido a que la información es abundante, el análisis de esta fase del estudio se ha hecho con las especies más conspicuas, ya que para un análisis más completo se requiere la identificación de todas las especies muestreadas, lo cual no ha sido posible hasta el momento, debido a que se le dió mayor importancia a la eficiencia del muestreo.

Se considera que el muestreo de la vegetación para complementar la evaluación de toda la zona ribereña, debe continuar en 1995.

Por otra parte, esta clasificación puede ser usada para análisis comparativos entre la cuenca del arroyo El Carrizal y otras áreas ribereñas de la región y adicionalmente puede ser útil en los siguientes aspectos:

1. Entender mejor la estructura y composición de la vegetación ribereña,
2. Establecer puntos de referencia para otros estudios de la vegetación ribereña, haciendo comparaciones de asociaciones, especies, etc.,
3. Proporcionar la información básica esencial para el desarrollo de planes de manejo de la cuenca,
4. Proporcionar las bases para definir hábitats críticos para la fauna silvestre, y
5. Generar una base de datos que puede ser usada de manera aislada o conjuntamente con otras bases de datos de tipo relacional (Baker *et al*, 1995), para obtener una mejor evaluación de las condiciones de la cuenca.

La separación grupal entre especies obligadas y facultativas es importante, para entender el grado de disturbio a partir de la vegetación natural del ecosistema ribereño, ya que el determinar el "grado de disturbio", permite hacer la evaluación de una cuenca y compararla con otra, respecto a las actividades de manejo forestal y de ganadería (pastoreo, intensidades de corta, etc.). De esta manera, si hay un alto grado de deterioro, la composición de las especies puede reflejar gran diversidad, pero pueden ser de tipo ruderal o incluír numerosas especies introducidas.

En otras ocasiones, algunas especies acuáticas obligadas, importantes en algunas localidades, como los géneros *Carex* o *Juncus* pueden no estar presentes, debido posiblemente a las condiciones de disturbio por la baja estabilidad de la rivera, derrumbes en el canal, confinamiento de la zona ribereña y una probable fase disclimax por pastoreo.

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Clasificación morfológica de los canales de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

Juan Espinoza Aréchiga[1], Alvin L. Medina[2] y Alberto Gómez-Tagle[3]

Resumen.—Se realizó la clasificación morfológica de los canales de la parte alta de la cuenca, como base para diagnosticar la cuenca del arroyo El Carrizal y se describieron los canales por medio de características como: pendiente, ancho, profundidad, tipo de lecho, pendiente de los taludes, relación ancho-profundidad en sitios cada 50 m. La cuenca fue dividida en tres partes: baja, media y alta. Los resultados indican que los causes son principalmente de tipo A, según la metodología de Rosgen (1994), y sus características son: confinados, con poca relación ancho-profundidad de su cauce, poco sinuosos y con pendientes superiores a 2%. Se observaron materiales dominantes del tipo intermedio a pequeño, de los subtipos 5 y 6, que indican perturbación aguas arriba con sedimentos finos por tracción en el fondo. La metodología mostró que con gran rapidez se determina el tipo de perturbaciones ocasionadas por la erosión y como consecuencia la pérdida de los ecosistemas ribereños.

INTRODUCCIÓN

Dentro del proyecto de manejo y restauración de áreas ribereñas iniciado en agosto de 1993 para evaluar, monitorear y analizar el ecosistema ribereño de la cuenca del arroyo El Carrizal, ubicado en el municipio de Tapalpa, Jalisco, se desarrolló la clasificación morfológica de canales de montaña, elemento indispensable para generar y validar técnicas que ayuden a conservar los cuerpos de agua.

Mediante este trabajo se cuantifican y clasifican las condiciones en que se encuentra el cauce de los canales, constituyendo un indicador importante y de obtención rápida de las condiciones en que se encuentra la cuenca. En México se carece de esta experiencia ya que el criterio principal para manejar los cuerpos de agua ha sido eminentemente hidráulico y no ecológico ó de manejo de ecosistemas.

El resultado ha sido el secamiento de numerosos manantiales, ríos y arroyos que aumentan las áreas con condiciones de aridez y deterioro. La causa primordial es que por desconocimiento, no se toma en cuenta la interacción entre condiciones hidromorfológicas de la red hídrica y la vegetación, el suelo y el tipo de uso que se da al área. Un grupo de tres investigadores determinó las características de los cauces en la cuenca citada, para relacionarlas con otros indicadores de la localidad y así definir los métodos de recuperación del ecosistema, que permitan mejorar la calidad y cantidad de agua para la población y el hábitat para la fauna.

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CARACTERÍSTICAS DEL ÁREA DE ESTUDIO

La cuenca del arroyo El Carrizal, se localiza en la Serranía de Tatalpa, al inicio de la cordillera del Eje Neovolcánico Transversal, en su parte más occidental, con una altitud promedio de 2,210 msnm, con la cota más baja a 2,000 msnm y la más alta a 2,420 msnm. La frontera de uso agropecuario se localiza a 2,060 msnm. Las coordenadas geográficas que enmarcan la cuenca en estudio son:

Longitud oeste:	103° 47' 03"— 103° 50' 21"
Latitud norte:	19° 50' 21"— 19° 55' 11"

Los parámetros hidromorfométricos de la cuenca son los siguientes:

• Área	1,170 Ha
• Longitud del cauce principal	8,500 m
• Longitud de 22 cauces secundarios	17,850 m
• Longitud de 30 cauces terciarios	9,200 m
• Perímetro	18,250 m
• Longitud axial	7,650 m
• Longitud del ancho	2,850 m
• Pendiente media del cauce principal	5.49 %
• Radio de bifurcación de cauces secundarios	0.045
• Radio de bifurcación de cauces terciarios	0.73
• Densidad de drenaje	31.68 m/Ha
• Coeficiente de compactación	0.47
• Radio de elogación de la cuenca	2.40
• Coeficiente de rugosidad	1.74
• Factor forma	0.2549
• Longitud promedio de afluentes secundarios	811.36 m
• Longitud promedio de afluentes terciarios	310.00 m
• Frecuencia de cauce de 1er orden	0.89/Km2
• Frecuencia de cauce de 2° orden	1.96/Km2
• Frecuencia de cauce de 3er orden	2.67/Km2

La cuenca del arroyo El Carrizal ha estado en aprovechamiento agropecuario y forestal desde hace muchos años, combinándose las actividades agrícolas y ganaderas en el mismo sitio. Recientemente las actividades agropecuarias se han limitado al área abajo de la cota 2,060 msnm para beneficio de los propietarios, procurando impedir el pastoreo en áreas arboladas, ya que los bosques se encuentran bajo el sistema de manejo integral (SIMANIN), que delimita perfectamente dicho uso del suelo y establece la total prohibición de pastoreo en áreas con plántulas en etapa de regeneración.

La superficie arbolada es de 912 Ha, las pendientes de sus taludes oscilan de 15 a 50 %, y es en esta zona donde los cauces secundarios alcanzan pendientes de 5 a 40 %.

Por esta razón su llanura de inundación es prácticamente nula, esto es que dichos cauces están perfectamente confinados. Sobre el cauce principal existen varios rápidos, con material madre de basalto, que en las caídas alcanzan hasta el 15 % de pendiente.

Los suelos de la cuenca del arroyo El Carrizal son de origen volcánico, originados en gran parte desde el Cenozoico Volcánico Superior, siendo dominantes los del tipo andosol y existiendo los de tipo cambisol, regosol y luvisol, con las variantes en los subtipos éutricos y órticos (Gómez-Tagle y Chávez-Huerta, 1986).

El clima se clasifica como templado subhúmedo, con lluvias en verano, que es largo y fresco, con sequía a mitad de verano; la oscilación térmica es 6° C, el mes cálido es anterior a junio, la temperatura media diurna es 16.81° C, la temperatura del mes más cálido es 19.3° C (mayo) y la temperatura del mes más frío es de 13.3° C (enero). Se presentan 284 horas frío y una precipitación pluvial total anual de 849.4 mm. La precipitación del mes más húmedo es de 169.7 mm (junio) y la del mes más seco es de 6.5 mm (febrero). Los porcentajes de precipitación pluvial mensual son del 4.2, con una probabilidad de lluvia de 47.8 % para la anual, el número de meses secos es de 7, de noviembre a mayo.

En cuanto a la vegetación arbórea, la cuenca del arroyo El Carrizal presenta en mayor proporción bosques de pino, seguido de bosques mezclados de pino-encino y en menor proporción latifoliadas puras, siendo la importancia de cobertura del género *Pinus* la siguiente:

- *Pinus michoacana* (en casi toda el área en forma pura o mezclada).
- *Pinus oocarpa* (en todos los lugares de menor calidad, en suelos pobres y/o erosionados).

- *Pinus pseudostrobus* (su distribución es restringida y en bajos porcentajes).
- *P. lumholtzii* (exclusivamente en suelos donde ya se perdió el horizonte o aflora en partes o totalmente el material madre).

Las latifoliadas representantes de la vegetación arbórea son: *Quercus resinosa, Q. rugosa, Crataegus mexicana* (esta especie está considerada como invasora en el bosque de pino), *Arbutus* spp., *Alnus arguta, Prunus brachibotrya, Salix oxylepis, Cornus excelsa, Fraxinus uhdei* (Chávez-Huerta *et al.*, 1995)

METODOLOGÍA DE TRABAJO

Después de un reconocimiento aerofotográfico completo y de recorridos terrestres, se inició el estudio para la clasificación de morfología de canales por tipos.

Se midió la pendiente entre una y otra, con punto de partida 700 m aguas arriba del sitio denominado El Carrizalillo, ya que es aquí en donde se inicia la definición clara del cauce principal y es en donde se localiza el primer manantial aguas arriba, que se forma bajo la elevación conocida como El Divisadero (el segundo punto más elevado de la cuenca), a 2,400 msnm.

La pendiente fue medida sobre el espejo del agua y se expresó en porcentaje. Los acotamientos o estaciones fijados cada 50 m fueron señalados con pintura sobre el árbol más cercano a cada estación, a la altura del diámetro normal (DAP). Se optó por el sistema de numeración de distancias (x+50), en donde x corresponde al número de la estación anterior y el número (50 m) a la distacia entre una y otra estación.

El número de estaciones fue de 122, por lo que a la última correspondió el señalamiento 122+50, que transformado a distancia sobre el cauce, corresponde a 6,100 m desde la estación de origen.

No obstante que el cauce principal tiene una distancia mayor, solo se acotaron 6,100 m, debido a que es en ésta donde se encuentra el vertedor de aforo con el equipo de monitoreo de calidad y gasto del agua del cauce principal, además de estar instalado un pluviógrafo.

Una vez concluido el acotamiento, se procedió a la toma de datos a lo largo y en el cauce principal relativos a: el sedimento dominante en el fondo del cauce; el ancho y la profundidad del mismo, apreciado con referencia a las huellas de mojado dejadas en las márgenes por avenidas normales; asimismo, los tramos en donde se presentaban cambios muy visibles de sinuosidad; la vegetación de ribera; forma de los taludes hacia el cauce y en donde afloraba el material madre.

Con los primeros y con los últimos datos se procedió a elegir los tramos que se consideraban diferentes unos de otros, para efectuar la calificación de los tipos de canales y su posterior levantamiento formal, que consistió en identificar claramente la sección del tipo de canal y luego en poner tres estacas a 20 cm del borde del cauce y distantes entre si 20 m (dentro del tramo del tipo de canal a levantar). En los puntos de las estacas, se señalaron 3 transectos transversales al cauce que en conjunto forman un sitio, poniendo en cada uno de ellos 2 estacas adicionales a uno y otro lado del mismo.

Las estacas que señalaron cada sitio, se fijaron sobre el talud que define el cauce, con un hilo sostenido a nivel y una cinta flexible, graduada en centímetros.

De esta forma se tomaron los siguientes datos:

- Profundidad o distancia del hilo a nivel al piso, incluyendo el cauce, a cada 50 cm.
- Distancia en donde se inicia y termina el agua del cauce (ambas márgenes), con relación al extremo derecho del hilo nivelado, observando esto en posición aguas arriba.
- Pendiente del cauce, del primer al tercer transecto transversal, en cada tipo de canal, todo esto fue medido sobre el espejo del agua.
- Pendiente de los taludes, en el segundo transecto transversal de cada sitio.

Una vez concluido el levantamiento de cada sitio, se señaló el mismo con una cinta ahulada, visible a simple vista, en la que se anotó el número de sitio correspondiente, dejando fijas las estacas en el sitio en donde se levantó cada transecto.

Los datos tomados en campo se procesaron para obtener primero la configuración altitudinal y de pendiente entre estaciones acotadas, a lo largo del cauce en los 6,100 m de longitud levantados; y después se procesaron los datos levantados en cada sitio.

RESULTADOS Y DISCUSIÓN

A continuación se muestran los resultados de longitud en cada tipo diferente de canal encontrado con relación a la longitud total estudiada y a la suma de la longitud de todos los tramos:

Al inicio del arroyo El Carrizal, se detectó el tipo A, en los primeros 150 m, siguiendo el tipo G, luego los tipos C, B, E y F, para dominar, a partir de los 1,500 m desde el origen del cauce, el tipo A, con los subtipos anotados en el Cuadro 1.

Los canales de tipo A indican lo siguiente:

- Bien confinado.
- Baja relación ancho-profundidad del cauce.
- Poca o nula sinuosidad.
- Pendiente de 2 a más de 10 %.

Los canales de tipo B indican lo siguiente:

- Moderadamente confinado.
- Moderada relación ancho-profundidad del cauce.
- Moderada sinuosidad.
- Pendiente de menos de 2 hasta 9 %.

Los canales de tipo C indican lo siguiente:

- No confinados.
- Relación ancho-profundidad del cauce de moderada a alta.
- Muy sinuosos (alta sinuosidad).
- Pendiente de menos de 1 hasta 3.9 %.

Los canales de tipo F indican que:

- Están bien confinados.

Cuadro 1. Tipos de canales en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco.

TIPO DE CANAL	DISTANCIA (m)	TRAMOS	%(1)	%(2)
A1	50	2		
A2	50	1		
A3	50	2		
A4	50	1		
A5	100	1		
A1a+	50	1		
A1b	50	1		
A2b	50	2	23	70
A3b	200	2		
A4b	350	5		
A5b	150	3		
A5a+	50	1		
A6a+	50	1		
A6b	150	3		
B3c	50	1		
b6	168	1	4.4	13.1
B6c	50	1		
C5b	100	1		
C6b	46	1	2.4	7.2
F5b	100	1	1.6	4.9
G6	47	1		
G6c	50	1	1.6	4.8
Totales: 22 subtipos	2,011	34	33.0	100.0

Rosgen (1994).

- Presentan moderada relación ancho-profundidad del cauce.
- Alta sinuosidad.
- Pendiente de menos de 2 hasta 3.9 %.

Los canales de tipo G indican que:

- Están bien confinados.
- La relación ancho-profundidad del cauce es moderada.
- Moderada sinuosidad.
- La pendiente es de menos de 2 hasta 3.9 %.

Los subtipos 1 al 6 indican los siguientes materiales dominantes en el fondo del cauce: material madre, rocas de 10 a 60 pulgadas de diámetro; piedras de 2.5 a 10 pulgadas de diámetro; gravas de 0.08 a 2.5 pulgadas de diámetro; arenas, arcillas y limos finos.

CONCLUSIONES

Del estudio que se realizó, se hacen las siguientes conclusiones:

Mediante la técnica empleada, se determinó que se debe tener cuidado de no destruir las riberas, que son frágiles debido a la erodabilidad de los suelos y las pendientes.

El cauce principal del arroyo El Carrizal, presenta como tipo dominante el A, muy bien confinado, con poca relación ancho-profundidad del cauce, poco sinuoso y con pendientes superiores a 2%, con materiales dominantes del tipo intermedio a pequeño y en donde se encuentran los subtipos 5 y 6, significa perturbación aguas arriba por los sedimentos finos de tracción de fondo.

Debido a la falta de conocimiento, el arroyo y los manantiales se usan mucho como abrevaderos para el ganado, los caminos se cruzan en muchos puntos, hay minas de piedra bajo aprovechamiento y la erosión de cunetas de los caminos azolva el lecho de los cauces, lo que provoca el disturbio del ecosistema.

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Características de la precipitación pluvial en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco

Juán de Dios Benavides Solorio[1], Malchus B. Baker, Jr.[2] y Esteban Talavera Zúñiga[1]

Resumen.—En este trabajo se describe la precipitación pluvial presente en Tapalpa, Jalisco durante un lapso de 51 años; la información proviene de la estación meteorológica cercana a la población. Los datos fueron tomados del año 1943 a 1993, de ellos se obtuvo una precipitación pluvial media de 901 mm, el rango en el que fluctúa es de 548 mm para el año más seco y de 1,549 mm para el año más lluvioso. El 80% de la precipitación pluvial anual promedio se presenta en los meses de junio a octubre. Antes de la temporada de lluvias, se tiene una época seca que comprende de febrero a abril, con un promedio de precipitación de tan sólo 11 mm por mes. Dentro de la cuenca se instalaron cuatro pluviógrafos automáticos que permiten conocer cual es la precipitación pluvial, éstos se ubicaron: uno junto al vertedor de la cota a 2,065 msnm, otro en el parteaguas a 2,420 msnm y dos en la parte media (uno al oriente y otro al poniente de la cuenca). La cantidad de lluvia recibida en la cuenca entre mayo y octubre de 1994 fue de 957 mm.

INTRODUCCIÓN

La precipitación pluvial es el mecanismo de entrada del agua a una cuenca hidrográfica y es la llave para la producción dosificada durante la época seca. El régimen de precipitación pluvial afecta la cantidad, la oportunidad y la distribución espacial del agua añadida a la cuenca y también juega un papel importante en la determinación de los tipos de suelo y vegetación que se encuentran en ella.

El conocimiento de la distribución de la precipitación pluvial es importante para distinguir cuando se presenta la estación de crecimiento de las especies vegetales y definir la época crítica para las mismas, además permite saber cuando se tendrán problemas con la erosión hídrica.

La precipitación pluvial es el resultado de diversos factores meteorológicos, los cuales, en gran medida están fuera del control humano. El uso del suelo y las alteraciones en la vegetación pueden afectar el papel de la precipitación pluvial por cambios en la intercepción de las gotas de lluvia. Para iniciar el estudio de una cuenca, es necesario conocer información básica acerca del régimen de la precipitación pluvial con la finalidad de entender todos los demás procesos que están ocurriendo dentro de la misma.

El propósito del presente trabajo fue conocer el régimen de precipitación pluvial durante varios años en Tapalpa, la distribución de la lluvia en forma mensual y la cantidad de lluvia y su distribución dentro de la cuenca.

ÁREA DE ESTUDIO

La cuenca del arroyo El Carrizal se encuentra cerca de Tapalpa, Jalisco (Figura 1), en la Sierra de Tapalpa, parte del sistema montañoso conocido como Eje Volcánico Transversal. Los bosques son templados, compuestos principalmente por especies de los géneros *Pinus* y *Quercus*. El rango de elevación de la cuenca varía de 2,000 a 2,420 msnm. La precipitación media anual es de 901 mm

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(promedio de 51 años, de la estación meteorológica de Tapalpa, Jalisco). El clima es templado con baja humedad, mayo es el mes más caliente y precede al inicio de la temporada de lluvias. Normalmente las lluvias inician en junio y finalizan en octubre.

El área boscosa dentro de la cuenca comprende una superfície aproximada de 912 Ha y es usada principalmente para la producción de madera y resina. La parte baja de la cuenca, que comprende alrededor del 20% de la superfície total, es usada para la agricultura y pastoreo de ovejas.

MÉTODOS

Se obtuvo información de la estación meteorológica de Tapalpa, Jalisco y de la Comisión Nacional del Agua en Guadalajara, Jalisco, correspondiente a 51 años sobre precipitación mensual a partir del año de 1943 y fue usada para caracterizar la precipitación pluvial anual y establecer el régimen de la temporada de lluvias para toda el área.

También fueron instalados cuatro pluviómetros portátiles y automáticos en la cuenca del arroyo El Carrizal (Figura 2), uno ubicado en la parte alta de la cuenca, dos en puntos opuestos del perímetro en la parte media y otro en la parte baja, instalado en el sitio donde se encuentra el vertedor (Figura 3).

Estos pluviómetros automáticos almacenan la información de la lluvia, en módulos pequeños que permiten incorporarla a una computadora personal (PC). Se utilizó el Método de Thiessen para calcular la lluvia promedio de la cuenca.

Figura 1. Ubicación de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

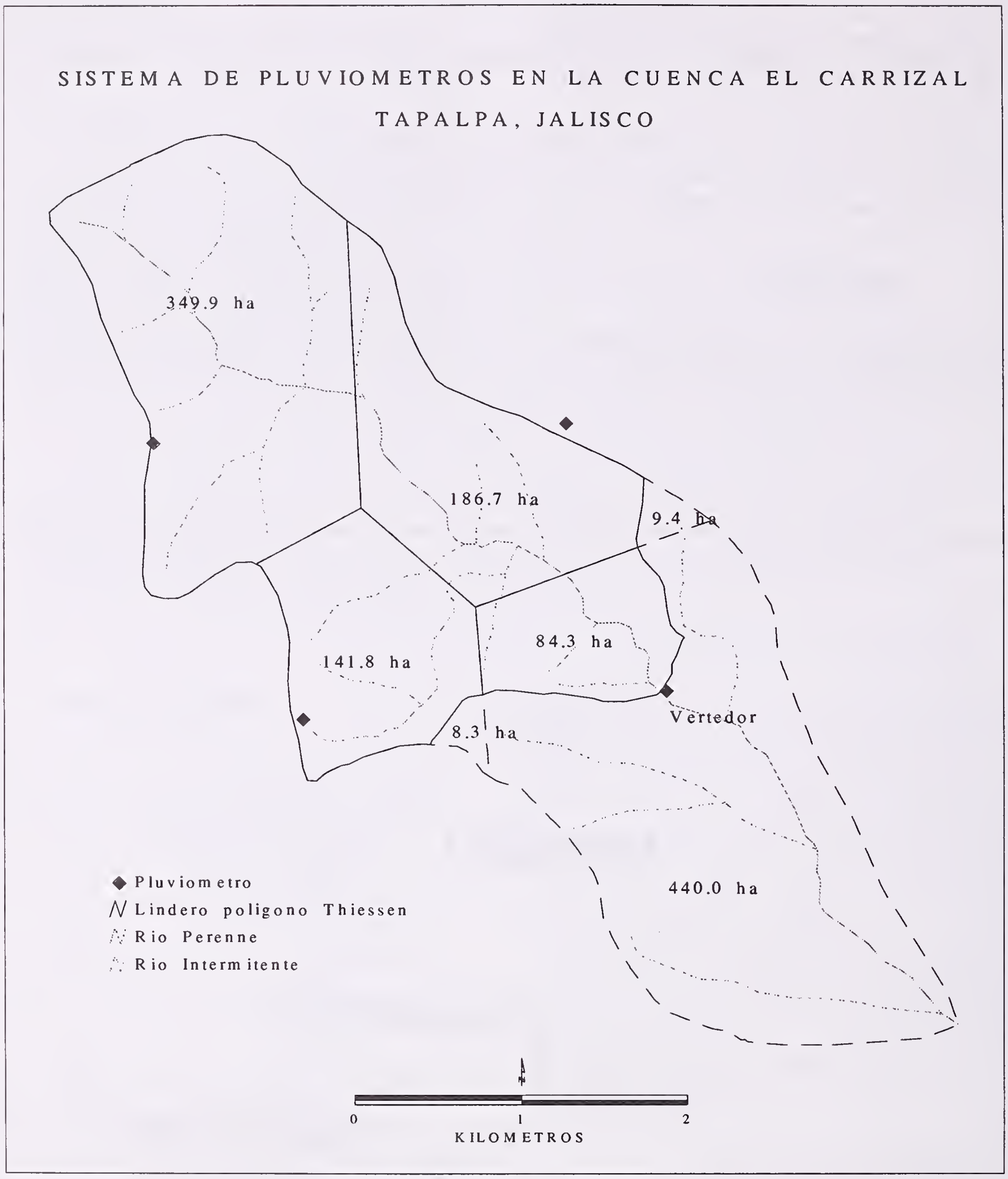

Figura 2. Pluviómetros portátiles, empleados para captar y medir el agua de lluvia en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

Los datos de precipitación pluvial dentro de la cuenca con estos pluviómetros se obtuvieron a partir de abril de 1994. La probabilidad de lluvia se estimó según Brooks *et al.* (1991); con el cálculo del período de retorno, con la fórmula:

$$Tr = n+1/m$$

y el período de retorno a una cierta probabilidad:

$$Tr = 1/p$$

donde:

Tr = período de retorno
n = número de años de registros
m = rango ordenado de los datos
p = probabilidad

y la probabilidad de ocurrencia del evento al menos una vez, en un número de años N es la siguiente:

$$Prob = 1 - (1-p)\ N$$

RESULTADOS

Precipitación pluvial por períodos

La precipitación media anual es de 901 mm (Cuadro1), con un rango de 548 a 1,549 mm, el período de información es de 51 años que comprende de 1943 a 1993.

La precipitación durante el lapso de 51 años se puede dividir en 5 períodos, comprendidos dentro de las siguientes características: un período de sequía similar al promedio, un irregular, uno lluvioso, otro de sequía y probablemente el inicio de otro irregular. (Figura 3).

Seco 1943-1953.— Durante los años de 1943 a 1953 (Figura 3) existieron algunos años secos, pero en otros se obtuvieron datos tendientes al promedio o escasamente por arriba de él, se

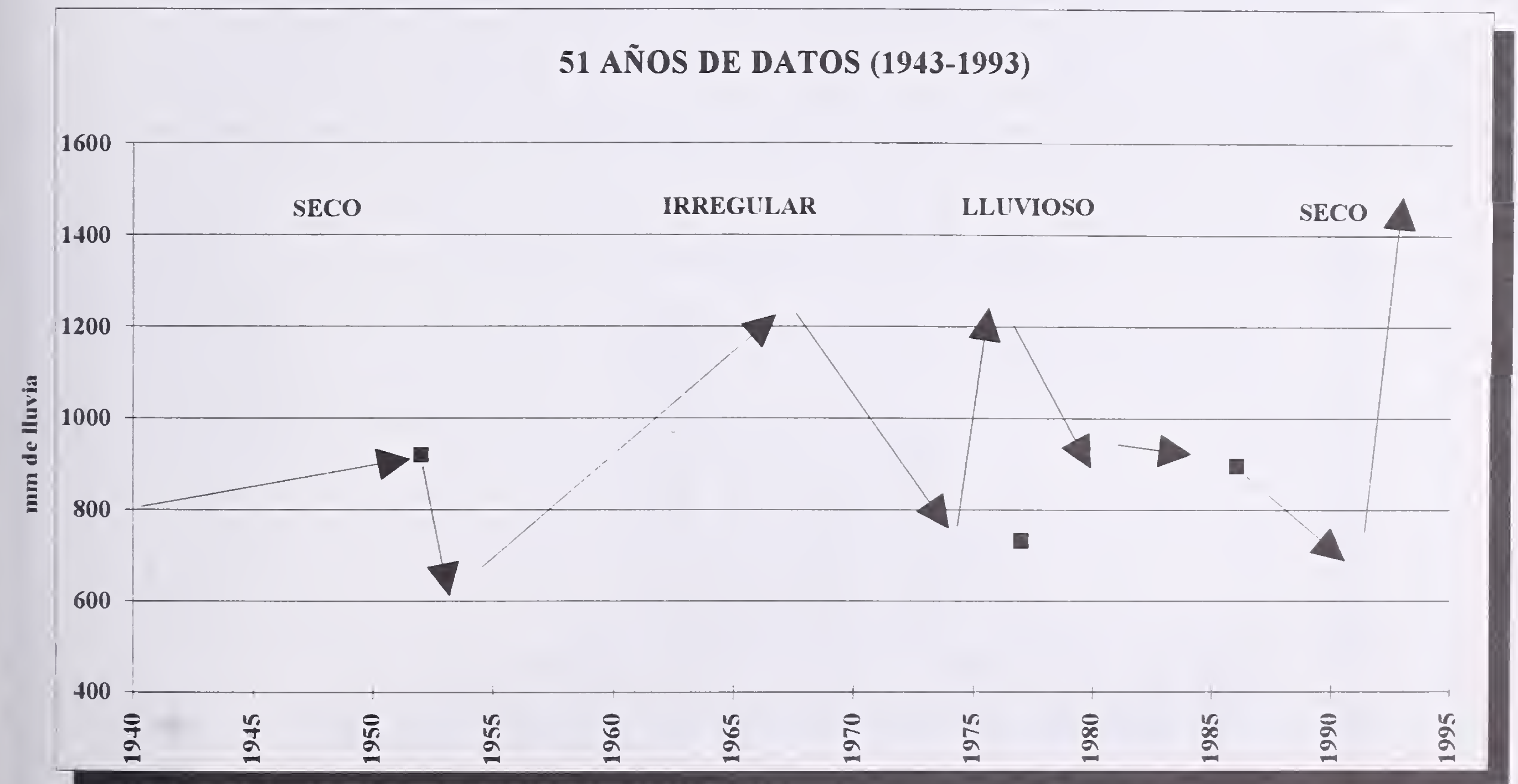

Figura 3. Distribución de la precipitación durante 51 años (1943-1993) con identificación de períodos regulares de lluvia, en Tapalpa, Jalisco, México.

Cuadro 1. Cantidad de precipitación pluvial por mes y año, en el período de 1943 a 1993, registrada en la estación meteorológica de Tapalpa, Jalisco, México.

Año	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dic	Total
1943	18.1	4.7	0	1	66.8	208.8	94.6	126.9	162.2	119.8	3.2	26.1	834.2
1944	28.4	8	66.1	0	34.2	193.7	71.3	192.3	266.4	40.4	38.4	0	939.2
1945	3.4	0	1.2	1.9	56.6	136.3	187.8	105.9	146.8	72.3	4.3	0	716.5
1946	53.5	0	6	17.7	1.5	257.3	187	133.4	109.9	136.7	56.6	51.2	1012.8
1947	81.1	0	30.5	0	32.5	143.5	69.5	215.9	105.3	139.5	16	42.8	876.6
1948	36.9	0	0	8.7	77.6	222.9	93.4	212.4	112.2	102	69.6	23.5	959.2
1949	1	7.2	3	0	22.5	137.8	133.6	147	32	63.8	0	0	547.9
1950	2.5	16.6	2.8	0	136.5	232.2	159.4	79.9	228.2	67.3	0	0	925.4
1951	8.8	0	19	0	57.5	159.5	117.5	165.5	134.9	96.6	73.4	5.7	838.4
1952	4.7	10.7	0	26.6	75.5	345	160.7	83.6	152	12.5	35.9	6.6	919
1953	0	0	0.3	2.7	37.8	124.6	106.1	174.7	70.9	121.3	51.6	52.5	742.5
1954	0	38.3	0	1	93.3	232.3	121.3	158.8	96	137.3	81.9	0	960.2
1955	6.5	0	0	7.2	121.2	166.6	207	195.3	217.1	107.1	23.9	14	1067.9
1956	0	0	0	8.8	159.6	161.9	134.6	191.3	140.1	34.7	20.5	8.8	880.3
1957	0	0	1.8	0	6	141.2	89.1	57.9	73.9	162.6	30.5	0.5	563.5
1958	94.3	12.5	6.1	0	64.2	166.2	213.3	222.8	64.3	254.3	96.4	22.2	1218.6
1959	12.3	0	0	131.7	109.2	165	112.4	140.7	179.5	156.6	0	1	1008.4
1960	0	0	0	0	5	176.1	193.7	224.4	86.8	91.6	1.8	34.5	813.9
1961	68.6	0	12.7	21.8	12	284.9	157.8	136.2	110.5	77.3	9.4	0	891.2
1962	3.5	1	0	2	25.5	134.4	77.2	92.3	127.9	71.7	65.3	4.5	605.3
1963	0	2	10.8	23.5	116.3	304.3	203.8	75.1	141.1	144.5	78.5	127.8	1227.7
1964	8.3	0	0.4	13.5	23.8	71.8	165.5	82.7	170.1	70.4	43.4	27.4	677.3
1965	20	45.5	0	6.3	38.2	68.9	134.6	127.1	184.6	103	7.7	76.7	812.8
1966	29.3	44.8	18.4	44	72	175.8	110.9	164.9	209.8	150.7	0	12.9	1053.3
1967	165.7	0	1.5	18.5	101.1	140.6	68.6	158	282.6	132.8	39.6	54.3	1163.3
1968	0	61.6	215.9	5.6	92.4	183.6	195.8	102.9	158.4	83.7	14.9	79.4	1174.2
1969	0	3.1	0.7	0	45.5	140.4	216.5	127.9	133	199.8	0	34.2	901.1
1970	2.2	19.2	0	0	25.5	306.1	160.5	120.2	161.3	95.4	24.7	0	917.1
1971	8.5	0	28.3	6.7	58.6	331.5	90.9	189	260.7	197.8	65.7	3	1240.7
1972	31.6	0	18.9	0	103.6	336.3	176.8	133.7	110.4	40.3	60.1	3.2	1014.9
1973	20	17.4	0	0	93.6	149.1	193.9	118	171	144.7	11	0	918.7
1974	24	16.1	5.3	25.5	92.2	145.9	288.4	85.4	153	80	14.2	19.8	949.8
1975	62.2	0	0	0	53.8	180	165.1	180.5	158.8	72.2	1.4	5.3	679.3
1976	4.9	2	0	2.5	9.2	139	276.2	61.4	109.7	155.6	181.5	16.5	958.5
1977	8.2	12	0	20.2	22.4	233.6	103.3	108.7	78.4	101.5	29.9	14.8	733
1978	2.4	34.5	2.6	0	32.2	97.5	86.2	218.7	138	127.5	8.1	12.5	760.2
1979	3.7	60.8	0	0	91.1	120.9	280.3	165	79.5	14.6	0	44.3	850.2
1980	149.6	9.6	0	0	38.6	152.4	141.9	92.6	108.1	100.7	61	24.9	879.4
1981	93.6	13.4	15.2	19.9	35.7	111	161.3	89.2	149.6	89.7	28.5	4.8	811.9
1982	0	7.8	0	13.4	37.8	102.7	109.4	108.5	129.1	61.6	122.8	59.4	762.5
1983	36.3	2	0	0	113.5	170.2	241.4	146.4	92.1	47.6	36.5	1.7	887.7
1984	40.3	6.1	5	0	69.5	161.1	285	116.7	178.9	33.9	0.6	33.5	930.6
1985	8.4	5.3	12.2	0	45	338.6	206.7	84.2	123.2	174.4	26.5	34.2	1058.7
1986	8.3	8.5	0	17.5	52.2	242.1	216	72.8	77.7	179.3	12.4	9.2	896
1987	8.9	41.5	0	7.8	50.3	206.2	226.1	66.5	115.58	2.3	25	3.4	753.58
1988	3.5	0	34.4	0.5	0	113.2	185.7	127.8	176.5	45.6	32	3	722.2
1989	0	4.2	0	0	5	125.5	102.1	153	72.2	122.4	59.1	61.7	705.2
1990	1	57.7	28.1	34	94.3	151.3	176.5	137	171.7	100	9	8.5	969.1
1991	11	0	0	0	2	149.5	244.3	89.5	133.1	49.6	88.3	30.4	797.7
1992	527.7	11.9	0	89.4	129.3	83.5	145.3	169	24.4	236.5	54.5	77.7	1549.2
1993	43.6	0	0	0	3.7	163.8	164.4	110	91.7	104.1	15.1	0	696.4
Prom	33.6	11.2	10.6	11.2	57.9	180.9	161.0	134.5	136.5	104.1	35.9	23.2	901.2

presentaron años alternados con secos y otro año lluvioso por arriva del promedio. En este período se obtuvo el año más seco de los 51 años, el de 1949, con una precipitación de 548 mm. La lluvia estuvo generalmente en un intervalo de entre 700 y 900 mm, con excepción del año 1949 ya comentado y del año 1946 que presentó 1,013 mm. El promedio de lluvia de este período fue de 846 mm.

Irregular 1954-1965.— El siguiente período se puede definir como irregular ya que de un año a otro o con intervalos de dos años (Figura 3), se presentaban diferencias muy altas en la cantidad de lluvia. En este lapso hay registros anuales que varían de 600 hasta 1,200 mm. El promedio de lluvia fue de 894 mm.

Lluvioso 1966-1976.— A continuación se presento otro período constante con lluvias por arriba de los 900 mm (Figura 3), con excepción del año de 1975 que tuvo 879 mm. Fue frecuente en este lapso la lluvia anual superior a 1,000 mm, incluso en 1971 la precipitación pluvial ascendió a 1,240 mm. El promedio de este período fue de 1,015 mm.

Seco 1977-1991.— Este intervalo comprendió 15 años y fue el período más largo (Figura 3); se consideró como seco porque la precipitación siempre estuvo por abajo del promedio, fluctuando entre 700 y 900 mm, con excepción de los años de 1984, 1985 y 1990 cuyos valores fueron de 930, 1,058 y 969 mm, respectivamente. El promedio de este período fue de 834 mm.

Irregular 1992-1993.— Después del período seco aparentemente se presentará otro período irregular que inició en el año de 1992 con una temporada extraordinária (Figura 3), cuando hubo problemas serios de inundaciones ya que la precipitación pluvial anual llegó a 1,549 mm comparado con los 528 mm que cayeron en el mes de enero. Al año siguiente se registró una precipitación baja de 696 mm.

Precipitación mensual

El período de lluvias regular de un año normal se establece durante los meses de junio a octubre (Figura 4), con una precipitación media de 717 mm, que equivalen a 80% de la precipitación pluvial anual. En la mayoría de los años el período de lluvias inicia a finales de mayo, pero se establece bien hasta junio; en el período de mayo a octubre se registra una precipitación media de 774 mm que equivale a 86% del total anual.

Los meses más lluviosos son junio y julio, con un promedio de precipitación pluvial de 181 y 161mm respectivamente, aunque se han presentado años extraordinários con meses fuera del rango promedio, han habido registros muy por arriba de los meses lluviosos, como fue el caso del

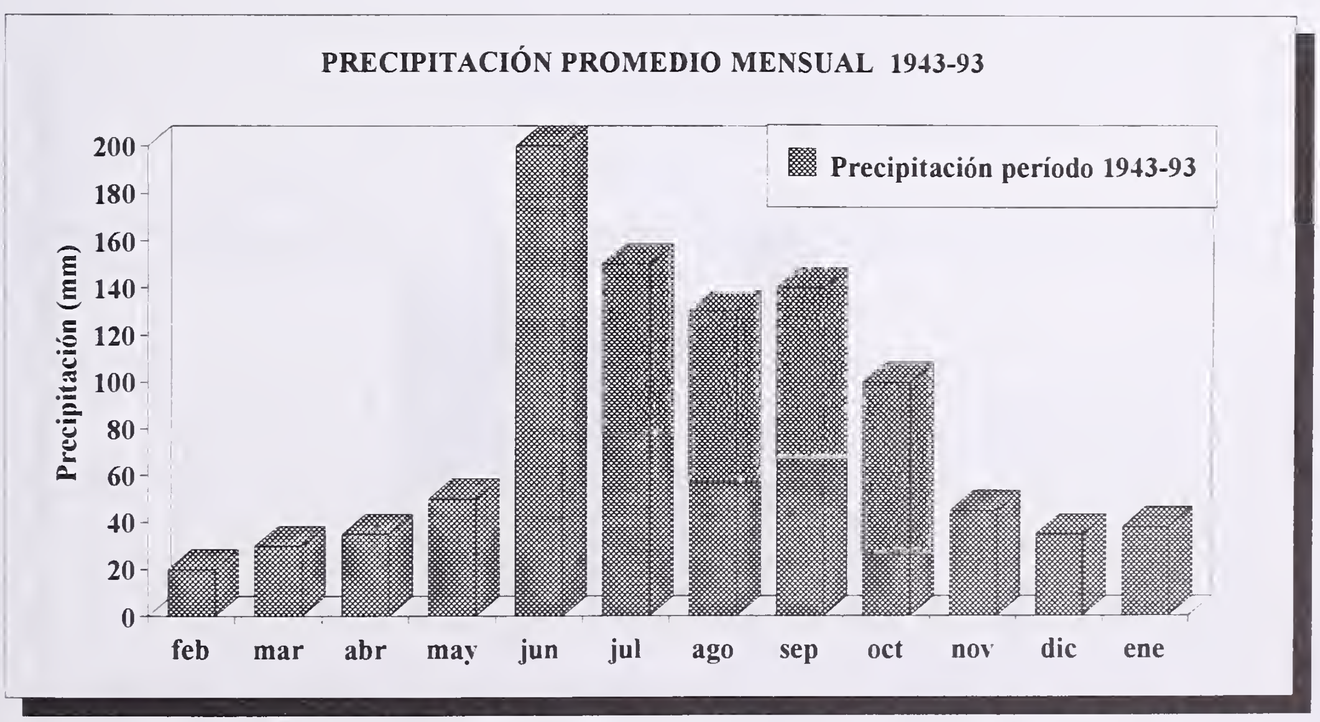

Figura 4. Distribución del promedio de la precipitación pluvial mensual con información de 51 años (1943-1993) en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

mes de marzo de 1968, que tuvo 216 mm y el de enero de 1992 en que se presentó una precipitación pluvial de 528 mm (Figura 5).

El período de lluvia es antecedido por tres meses secos (de febrero a abril), los cuales tienen un promedio de precipitación pluvial de 11 mm por mes. Los meses de noviembre a enero tienen un promedio de 36 mm o menos (Figura 4).

La lluvia precipitada dentro de la cuenca durante el año de 1994 fue medida con pluviómetros automáticos, durante los meses de mayo a octubre, en que se alcanzaron 957 mm (Figura 6).

Figura 5. Precipitación pluvial mensual promedio, comparada con la de los años 1968 y 1992.

Figura 6. Precipitación pluvial mensual en la cuenca del arroyo El Carrizal, de mayo a octubre de 1994, captada en los pluviómetros portátiles.

Probabilidad de lluvia

En el cuadro 2 se presenta la probabilidad de lluvia para un año cualquiera dentro del rango de 10 años. Por ejemplo, las probabilidades de lluvia extraordinária de 1,500 o más, en los próximos 10 años son de únicamente 18% y dentro de 50 años, esperar otra lluvia de esta magnitud es de 63%. También se observa que la probabilidad de lluvia de 900 a 1,000 mm o más en un año cualquiera dentro los próximos 10 años es de más de 90%, mientras que lluvia de 1,100 mm es probable en 72%.

CONCLUSIONES

Las principales conclusiones del análisis realizado son:

- El 80% de la lluvia que cae sobre la cuenca del arroyo El Carrizal ocurre en verano, en el período de junio a octubre.
- La precipitación pluvial de la temporada de lluvia, es frecuentemente de alta intensidad, proveniente de pequeñas nubes convectivas.
- Las altas intensidades de lluvia tienen el potencial de producir severa erosión en suelos desnudos o en áreas con alta compactación de bajos niveles de infiltración.
- Aunque las altas intensidades de lluvia pueden tener un alto potencial de erosión, las pequeñas áreas de estos eventos limitan la extensión de la erosión.
- Las bajas precipitaciones durante el otoño y el invierno, aumentan el riesgo de incendios forestales en esta temporada.
- Se diferencían dentro de la distribución de la precipitación pluvial de 51 años cinco períodos, identificados como: seco de 1943 a 1953, irregular de 1954 a 1965, lluvioso de 1966 a 1976, seco de 1977 a 1991 y nuevamente irregular a partir de 1992.
- La probabilidad de esperar lluvia en los próximos 10 años de 900 a 1,000 mm o mayor es de 90%, disminuyendo conforme aumenta la cantidad de lluvia.

LITERATURA CITADA

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Cuadro 2. Probabilidad de lluvia en cantidades específicas en un año cualquiera dentro de los rangos de 5 y 10 años en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

AÑOS	Lluvia de 1,500 mm	Lluvia de 1,200 mm	Lluvia de 1,100 mm	Lluvia de 1,000 mm	Lluvia de 901 mm
5	9%	34%	47%	73%	92%
10	18%	56%	72%	93%	95%
20	33%	81%	92%	99%	100%
30	45%	91%	97%	100%	100%
40	55%	96%	99%	100%	100%
50	63%	98%	100%	100%	100%

Hábitat y ecología de reproducción de anfibios del bosque tropical deciduo de Jalisco, México

Paulette L. Ford y Deborah M. Finch[1]

Resumen.—Los bosques del trópico seco son algunos de los más amenazados de los bosques tropicales. En este artículo, hacemos una pequeña revisión de la historia de la vida de algunos anuros en el estado de Jalisco, México y discutimos su conservación en relación a los factores que limitan el uso del habitat y las oportunidades de reproducción. Se sabe que existen aproximadamente 19 especies de anuros en los bosques secos y tierras bajas de Jalisco. Los anuros se encuentran entre las muchas especies de organismos que han evolucionado para sacar ventaja de las variaciones estacionales extremas del trópico seco. Por ejemplo, los anuros pueden cambiar su periodo de reproducción, y algunos han desarrollado adaptaciones especiales que les permiten reproducirse en condiciones xéricas. Debido a que diferentes especies tienen diferentes hábitos reproductivos, se puede esperar un rango de respuestas a prácticas en el uso de la tierra como la corta de madera, el pastoreo, o la recreación. Consideramos a la transferencia de información sobre los requerimientos reproductivos de los anuros tropicales a los manejadores del recurso, como un paso inportante en el desarrollo de guías efectivas para su conservación.

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Abundancia, riqueza de especies y uso del habitat de aves terrestres residentes en la Cuenca del Lago de Pátzcuaro, Michoacán, México

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Resumen.—La cuenca del Lago de Pátzcuaro, localizada en la región centro-norte del Estado de Michoacán, México, ha sufrido grandes cambios y reduc-ciones en la calidad y cantidad de sus recursos naturales. Los efectos del deterioro de las condiciones ambientales en su diversidad faunística no han sido adecuadamente evaluados, con algunas excepciones, como el caso del pez blanco endémico de éste lago (*Chirostoma estor*). Para determinar el uso que hacen las especies de aves de los diferentes hábitats de la cuenca y evaluar el valor de esos hábitats para la diversidad avifaunística, se hicieron conteos de aves durante la época reproductiva en 1994 en siete tipos diferentes de vegetación, incluyendo bosques de pino-encino, de pino, de encino-pino, de encino, plantaciones de *Eucalyptus*, pastizales y matorrales. El muestreo se distribuyó entre los hábitats en proporción al área que cubrían en la cuenca. Un total de 75 estaciones de conteo fueron muestreadas y 70 especies fueron detectadas durante esos conteos. Encontramos que la riqueza de especies (cantidad media de especies/estación) y la abundancia (cantidad media de individuos/estación) fueron mayores en el bosque de pino (5.4 y 7.6, respectivamente) y menores en el pastizal (1.6 y 2.4, respectivamente). Ninguna especie individual se encontró en los siete tipos de hábitat, mientras que el 52 porciento de las especies se restringieron a un solo hábitat. En el bosque de encino se encontró la mayor cantidad de especialistas (12), mientras que en la plantación forestal se encontró la menor (1). Sesenta y seis porciento de las especies registradas fueron insectívoras. Los patrones de uso del hábitat variaron entre los diferentes gremios alimenticios.

INTRODUCCION

La cuenca del Lago de Pátzcuaro es un área de alto valor recreativo y de uso humano en la región norte-centro del Estado de Michoacán, México. Durante las dos décadas pasadas, esta cuenca ha sufrido grandes cambios y reducciones en la calidad y cantidad de sus recursos naturales, tales como agua, suelo, cobertura herbácea, bosques nativos y otras comunidades vegetales. La cuenca ha sido habitada por varios siglos por el grupo étnico Purépecha, manteniendo altas poblaciones humanas aun antes de la llegada de los españoles. Con una población actual de poco más de 100,000 habitantes (INEGI 1993), la mayoría viviendo en pobreza, los recursos naturales de la cuenca han

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sido intensamente utilizados (Toledo y Barrera 1984). Compañías extranjeras explotaron comercialmente los bosques de la región en el primer tercio de este siglo, removiendo casi completamente la cobertura forestal original, compuesta por bosques abiertos antiguos de pinos grandes (Edwards 1949). Desde entonces, los pobladores nativos han continuando cortando árboles en pequeña escala, no obstante que un decreto presidencial estableció una veda forestal total en la cuenca desde 1936 (CSE 1987).

La reducción en área de la vegetación natural y su conversión a agricultura, han resultado en un incremento de la erosión del suelo y la consecuente sedimentación del lago. Desde 1940, la profundidad del lago ha disminuído, los pantanos se han incrementado en área, el pez blanco endémico (*Chirostoma estor*) casi ha desaparecido, las malezas acuáticas (*Eichhornia crassipes*) se han vuelto un gran problema para la pesca y la navegación, y las poblaciones de aves acuáticas, principalmente patos y gansos se han reducido (Arellano y Rojas 1956, CSE 1987). En las partes altas de la cuenca, la explotación de los recursos forestales y su conversión a agricultura y ganadería extensiva, han degradado y puesto en peligro los hábitats de la fauna silvestre. Los efectos del deterioro de las condiciones ambientales en la diversidad faunística no han sido evaluados adecuadamente, excepto por algunas especies como el pez blanco endémico (Roja y Mares 1988).

Las aves de la cuenca del Lago de Pátzcuaro fueron motivo de atención de pocos colectores científicos al final del siglo pasado. El esfuerzo de muestreo y estudio más importante ocurrió en la década de 1940, cuando varias expediciones de museos de los Estados Unidos colectaron aves intensamente (Edwards 1949). El primer estudio ornitológico intensivo en la cuenca fue conducido por Ernest P. Edwards (Edwards 1949, Lea y Edwards 1950, Edwards y Martin 1955), quien registró 215 especies, de las cuales solo 71 fueron confirmadas como especies reproductivas. Desde el trabajo de Edwards, se han publicado muy pocos datos concernientes a la región de Pátzcuaro.

El objetivo de nuestro estudio es contribuir a los esfuerzos de manejo del ecosistema que se están llevando a cabo actualmente en la cuenca del lago de Pátzcuaro (ver el estudio de caso respectivo en este memoria). El propósito principal de este artículo es reportar resultados preliminares sobre cuantificación del uso de los hábitats que hacen las aves residentes en la cuenca e intentar determinar que hábitats son importantes en el mantenimiento de la diversidad de la avifauna dentro de la misma. La contribución de un área o hábitat a la diversidad biológica puede ser evaluada por medio de diferentes factores, incluyendo riqueza de especies, abundancia de individuos y especies únicas (Lagner y Flather 1994). Estos tres factores son usados para evaluar los hábitats en la cuenca. Adicionalmente, estos resultados preliminares son parte de un estudio a escala estatal de "evaluación rápida" de la diversidad biológica de Michoacán, usando aves como taxón indicador.

En este artículo, reportamos datos de conteos en 75 estaciones de muestreo estratificadas aleatoria mente entre los siete tipos de vegetación principales de la cuenca del Lago de Pátzcuaro. Las aves fueron muestreadas del 31 de mayo de 1994 al 25 de julio de 1994. Comparamos la riqueza de especies, abundancia relativa y composición de los gremios alimenticios a través de hábitats. Asignamos las especies a un gremio en particular, por el tipo dominante de alimento que consumen. Por ejemplo, los nectarívoros comen principalmente néctar, aunque también se pueden alimentar de insectos. También examinamos los patrones de especialización en uso del hábitat.

AREA DE ESTUDIO

La cuenca del Lago de Pátzcuaro forma parte del sistema lacustre localizado en el Eje Neovolcánico Transversal, en la parte norte de Michoacán. La cuenca tiene aproximadamente 100,000 hectáreas , con una altitud de 2,000 a 3,300 msnm. El lago cubre 10,000 hectáreas. La cuenca está rodeada por macizos montañosos hacia el oeste, norte y sur (CRAC 1981, Caballero y Mapes 1985, Díaz y Bello 1993). Aunque el clima es templado (temperatura media mensual = 16°C), con inviernos moderados, frecuentemente ocurren varios días con heladas (temperaturas bajo cero) en diciembre y enero. Una bien marcada estación seca se extiende de noviembre a mayo, mientras que la estación lluviosa se extiende desde junio hasta octubre. La precipitación media anual es de alrededor de 1,000 mm (Caballero y Mapes 1985, Díaz y Bello 1993).

Aproximadamente 51% de la tierra está dedicada a la agricultura, ganadería y asentamientos humanos. Cuarenta y nueve porciento está cubierto por vegetación natural primaria y secundaria. Los tipos de bosque incluyen: pino-encino, encino-pino, encino y pino, con matorrales, pastizales y plantaciones forestales entremezclados (Caballero y Mapes 1985). El bosque de pino-encino es dominado por *Pinus leiophylla, P. michoacana* y *P. lawsoni*, junto con *Quercus rugosa, Arbutus xalapensis* y *Alnus jorullensis* (Díaz y Bello 1993). El bosque de encino-pino es dominado por encinos (*Q. candicans, Q. obtusata* y *P. leiophylla*) mezclados con pinos esparcidos (*P. pseudostrobus*). El bosque de encino es dominado por *Q. laurina, Q. candicans, Q. obtusata, Tilia mexicana, Meliosoma dentata* y *Cornus disciflora* en el dosel. Los bosques de pino-encino, encino-pino y encino son los tipos de vegetación natural más extensos en la cuenca. El bosque de pino es dominado por *P. montezumae, P. teocote* y *P. leiophylla*. La vegetación arbustiva se caracteriza por la presencia de *Euphorbia calyculata, Bursera cuneata, Calliandra grandiflora* y *Opuntia tormentosa*. La mayoría de los pastizales son inducidos e incluyen especies como *Andropogon sacharoides, Bouteloua repens, Digitaria ciliaris* y *Panicum hallii*. Las plantaciones forestales son dominadas por una sola especie, como *Eucalyptus globulosa* o *Cupressus lindleyi*.

METODOS

Un diseño de muestreo al azar estratificado fue usado para localizar 75 estaciones de conteo dentro de la cuenca del lago de Pátzcuaro. Identificamos sietes tipos de hábitat basados en la clasificación usada en la Carta de Uso del Suelo y Vegetación, 1:250,000, del INEGI (1984), incluyendo bosques de pino, pino-encino, encino-pino, encino, plantaciones de eucalipto, matorral y pastizal. El mapa también fue usado para estimar el porcentaje de área cubierto por cada tipo de hábitat. Las 75 estaciones fueron divididas proporcionalmente entre los siete principales tipos de hábitat de acuerdo al porcentaje de área que cada hábitat ocupaba. Viente cinco estaciones se establecieron en el hábitat más común, pino-encino; 20 estaciones en bosque de encino; 10 en bosque de encino-pino; 5 en bosque de pino; 5 en plantación de eucalipto; 5 en matorral; y 5 en pastizal. Las especies se agruparon en gremios alimenticios usando varias fuentes como referencia (Ehrlich *et al.* 1988; Hutto *et al.* 1985, Hutto *et al.* 1986).

El método de conteo por puntos fue usado para muestrear las aves (Hutto 1986). Los conteos se llevaron a cabo desde las 7:00 a las 11:00 horas. Las aves vistas o escuchadas se registraron durante períodos de 10 minutos en cada estación, las cuales fueron muestreadas una sola vez. La vegetación fue muestreada en cada estación de conteo usando métodos delineados en Ralph *et al.* (1993). Los resultados del análisis del hábitat serán reportados en futuras publicaciones. El muestreo tuvo lugar desde el 31 de mayo de 1994 al 25 de julio de 1994.

En este análisis exploratorio, reportamos la composición de la comunidad de especies de aves, la cantidad de especies, la abundancia de aves en general y la cantidad de individuos por especie en cada uno de los siete hábitats de la cuenca. Para estandarizar las pruebas y los resultados, la riqueza de especies fue resumida como la cantidad media (±SE) de especies por estación de conteo, mientras que la abundancia fue resumida como la cantidad media (±SE) de individuos por estación de conteo. Usamos *análisis de la varianza de clasificación simple* para comparar la riqueza de especies, abundancia de todas las aves y abundancia de gremios alimenticios (omnívoros, carnívoros, insectívoros, granívoros, fugívoros, y nectarívoros) a través de hábitats. Se hicieron comparaciones múltiples a través de hábitats con la prueba de Tukey-HSD (*Honestly Significant Difference*). La abundancia y distribución a través de hábitats entre especies en los diferentes gremios se demuestra en forma de tabla.

RESULTADOS

Un total de 70 especies de aves fue registrado durante el muestreo (Tabla 1). De esas especies, 36 (51%) fueron encontradas en un solo tipo de hábitat, 17 (24%) en dos hábitats, 8 (11%) en tres hábitats, 3 (4%) en cuatro hábitats, 4 (6%) en cinco hábitats y 2 (3%) en seis hábitats. Ninguna especie en particular se encontró en todos los siete hábitats. Las comparaciones múltiples sugieren que el pastizal tuvo significatívamente menos riqueza de especies que los cuatro tipos de bosque

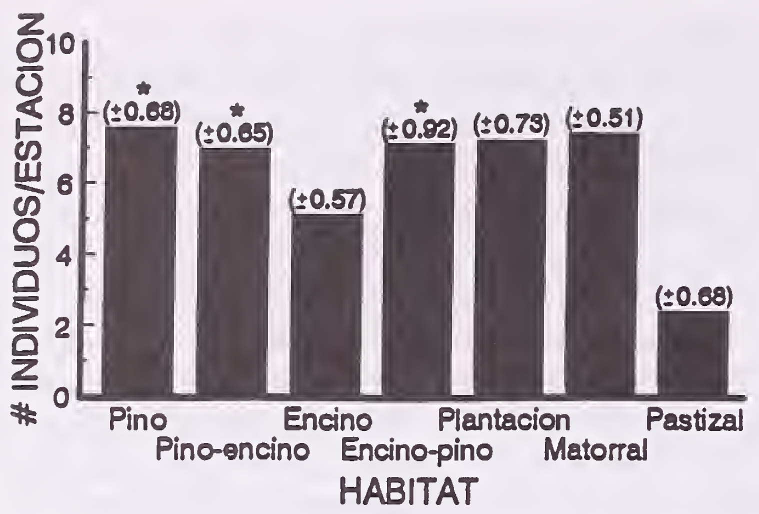

Figura 1. Cantidad media de especies de aves por estación observadas en siete tipos de vegetación en la cuenca del Lago de Pátzcuaro. Las cantidades entre paréntesis sobre la barras son error estándar de la media. Los asteriscos indican una diferencia significativa (P < 0.05, prueba de Tukey-HDS) en número de especies entre pastizal y otros tipos de vegetación. Las comparaciones pareadas entre otros tipos de vegetación no fueron significativas.

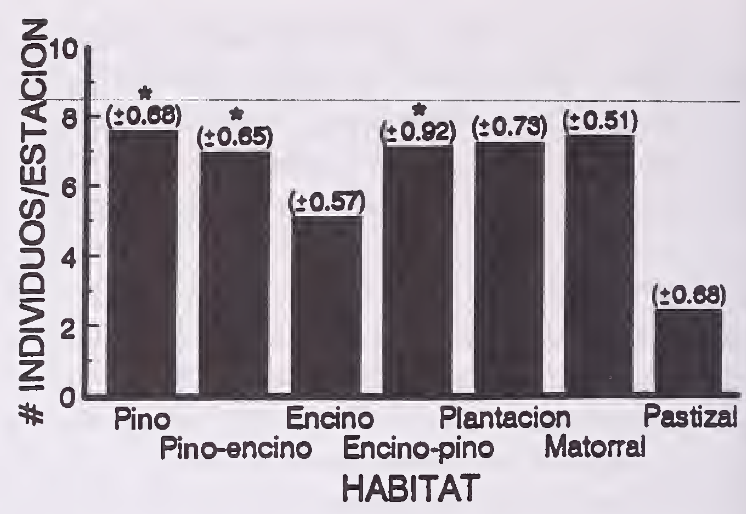

Figura 2. Cantidad media de individuos por estación observadas en siete tipos de vegetación en la cuenca del Lago de Pátzcuaro. Las cantidades entre paréntesis sobre la barras son error estándar de la media. Los asteriscos indican una diferencia significativa (P < 0.05, prueba de Tukey-HDS) en número de individuos entre pastizal y otros tipos de vegetación. Las comparaciones pareadas entre otros tipos de vegetación no fueron significativas.

natural (Figura 1). El bosque de pino tuvo la mayor riqueza de especies (5.40±1.10), seguido por el bosque de encino-pino (4.90±0.51), el matorral (4.80±0.37), el bosque de pino-encino (4.76±0.34), la plantación forestal (4.00±0.84), el bosque de encino (3.55±0.35) y el pastizal (1.60±0.24). En comparaciones de abundancia relativa, la cantidad media de individuos por estación difirió entre pastizal (menos individuos) y tres tipos de bosque (Figura 2). La mayor abundancia ocurrió en el bosque de pino (7.1±0.68), seguido por el matorral (7.4±0.51), la plantación forestal (7.2±0.73), el bosque de encino-pino (7.1±0.92), el bosque de pino-encino (6.96±0.65), el bosque de encino (5.1±0.57) y el pastizal (2.4±0.68).

Los patrones de uso del hábitat variaron entre gremios alimenticios, y la abundancia de individuos dentro de cada gremio varió a través de los hábitats (Tablas 1 y 2). La composición de especies fue dominada por los insectívoros (46 especies) seguida por los nectarívoros (6), los granívoros (6), los frugívoros (6), los omnívoros (3) y los carnívoros (3) (Tabla 2).

INSECTIVOROS.—Aunque los insectívoros fueron el único gremio encontrado en todos los siete hábitats, las especies individuales tendieron a restringirse a un sólo hábitat (23 especies, 50% de 46). En comparaciones múltiples, los insectívoros fueron más abundantes en el bosque de pino-encino que en el bosque de pino ($F_{6,67}$=2.4; P<0.05). El bosque de pino-encino fue usado por 28 (61% de 46) de las especies detectadas, mientras que la plantación forestal y el pastizal fueron usados por sólo 5 (11%) y 7 (15%) especies, respectivamente.

NECTARIVOROS.—Las especies nectarívoras fueron observadas principalmente en bosque de encino -5 de 6 especies (83%)- pero la abundancia no difirió significatívamente entre hábitats debido a su rareza y al tamaño pequeño de la muestra.

GRANIVOROS.—La riqueza de especies demostró poca variación entre hábitats. La abundancia de granívoros fue mayor en el matorral, la plantación forestal y en el bosque de pino, que en el pastizal, y en los bosques de encino, de encino-pino y de pino-encino ($F_{6,67}$=17.0;P<0.05). Los granívoros también fueron más abundantes en el bosque de pino, que en el matorral.

FRUGIVOROS.—Aunque su abundancia no difirió significatívamente entre hábitats, es notable que estas especies estuvieron ausentes en el matorral y el pastizal.

OMNIVOROS.—Estas especies estuvieron confinadas a cuatro tipos de bosque (pino, pino-encino, encino-pino, y encino) y fueron más abundantes en el bosque de encino-pino que en el de encino ($F_{6,67}$=2.1;P<0.05).

CARNIVOROS.—Las aves carnívoras fueron observadas solamente en el matorral y el bosque de encino y fueron más abundantes en el matorral que en el bosque de encino ($F_{6,67}$=2.2;P<0.05).

DISCUSION

Dos indicadores de la diversidad biológica y valor del hábitat son la riqueza de especies y la cantidad de individuos o abundancia. En este estudio encontramos que la riqueza de especies y la abundancia general de aves, fueron mayores en el bosque de pino y menores en el pastizal. La mayoría de los pastizales encontrados en la cuenca, son creados y mantenidos para uso de animales domésticos.

Otra medida de la diversidad biológica es la cantidad de especialistas, definidos en este estudio como especies restringidas a un solo hábitat. Los especialistas son importantes porque son particularmente susceptibles a la pérdida del hábitat. De 70 especies, 36 (51%) usaron sólo uno de los siete hábitats de la cuenca del Lago de Pátzcuaro. El bosque de encino tuvo el mayor número de especialistas (12), seguido por el bosque de pino-encino (10), el pastizal (4), el bosque de encino-pino (3), el bosque de pino (3), el matorral (3) y la plantación forestal (1). Notoriamente, el bosque de encino tuvo una alta cantidad de especialistas de hábitat, aunque tuvo bajos valores de riqueza de especies y abundancia de individuos. Esto sugiere que el bosque de encino provee recursos "clave" para algunas especies, recursos que fueron menos comunes o no disponibles en otros hábitats. Un ejemplo pueden ser los recursos de néctar, enfatizado por la presencia de nectarívoros (5 de 6 especies) en el bosque de encino. El bosque de pino tuvo pocos especialistas de hábitat, pero la mayor riqueza de especies y de abundancia de individuos. Esto demuestra que el bosque de pino, provee una gama amplia de recursos a un mayor número de especies e individuos, aunque los recursos "únicos" pueden no ser abundantes.

Al organizar a las especies en gremios alimenticios, se identificaron los patrones de presencia/ausencia de especies potencialmente relacionados a la disponibilidad de recursos tales como alimento o substrato alimenticio. El gremio con la mayor cantidad de especies fue el de los insectívoros, con 46 especies (67% de 70). Las altas cantidades de insectívoros en todos los hábitats sugieren que los insectos estan más fácilmente disponibles que otros tipos de alimento en las áreas muestreadas. Los gremios de frugívoros, granívoros y nectarívoros, cada uno con sólo seis especies representantes en total, no estuvieron bien distribuidos entre todos los hábitats. Los nectarívoros como grupo, demostraron el mayor grado de especialización por hábitat, con 5 de 6 especies encontradas sólo en bosque de encino. Los recursos de néctar pueden ser menos comunes que otros tipos de alimento en los otros hábitats muestreados. Debido a que el pastizal fue usado sólo por insectívoros, parece que este tipo de hábitat puede no ser suficientemente diverso en recursos alimenticios o en substratos de alimentación, como para atraer una rica variedad de especies de aves. Esto puede en parte, explicar por qué la riqueza de especies de aves fue menor en pastizal que en los otros hábitats. Los granívoros estuvieron presentes en todos los hábitats excepto en el pastizal, sugiriendo que los recursos de semillas y granos están disponibles (aunque no necesariamente abundantes) en la mayoría de hábitats

Los patrones de riqueza de especies y abundancia también pueden ser explicados en gran medida por la estructura de la vegetación, tal como la diversidad de altura del follaje (MacArthur y MacArthur 1961). Estas relaciones pudieran explicar la baja riqueza y abundancia de especies en el pastizal, el cual probablemente exhibe muy baja diversidad estructural vegetal. La correlación de los datos de hábitat y las medidas de diversidad de aves pueden explicar adicionalmente los patrones observados.

Nuestros resultados demuestran que una medida única de valor del hábitat no puede por sí sola explicar el rango total de complejidad de la avifauna de la cuenca del Lago de Pátzcuaro. Para conservar su diversidad biológica, recomendamos el uso de medidas múltiples de valor del hábitat que registren marcadas concentraciones y patrones de sobreposición de: 1) abundancia de individuos, 2) riqueza de especies, 3) situación de conservación de las especies, 4) especialización de las especies en el uso del hábitat, 5) endemismo de especies, 6) tasas y patrones de disminución de las poblaciones, 7) tasas de pérdida del hábitat, y 8) disponibilidad y rareza del hábitat.

Tabla 1.–Cantidad media de individuos por estación en siete tipos de vegetacion, y el numero total de hábitats en cuales se encontro cada especie. Las cantidades entre paréntesis son error estándar de la media. Las especies estan ordenadas por gremios alimenticios.

GREMIO	# de hábitats	HABITAT Pino	Pino-encino	Encino	Encino-pino	Plant-acion	Matorral	Pastizal
CARNIVOROS								
Buteo jamaicensis	1		0.04 (0.04)					
Cathartes aura	1						0.60 (0.60)	
Glaucidium species	1			0.05 (0.05)				
FRUGIVOROS								
Catharus aurantiirostris	5	0.20 (0.20)	0.28 (0.12)	0.30 (0.13)	0.10 (0.10)	0.60 (0.40)		
Catharus occidentalis	3		0.08 (0.06)	0.15 (0.11)	0.20 (0.13)			
Euphonia elegantissima	3		0.16 (0.09)	0.20 (0.20)		0.40 (0.24)		
Myadestes obscurus	3	0.45 (0.15)	0.28 (0.11)	0.10 (0.10)				
Ptiligonys cinereus	2		0.08 (0.06)		0.40 (0.27)			
Turdus assimilis	2		0.16 (0.09)	0.10 (0.07)				
GRANIVOROS								
Carduelis psaltria	6	2.00 (0.63)	0.12 (0.09)	0.05 (0.05)	0.20 (0.20)	1.00 (0.31)	0.20 (0.20)	
Aimophila ruficauda	2	0.20 (0.20)	0.12 (0.12)					
Carpodacus mexicanus	2					0.60 (0.60)	1.20 (0.20)	
Leptotila verreauxi	1	0.20 (0.20)						
Pipilo fuscus	1		0.08 (0.06)					
Zenaida macroura	1	0.20 (0.20)						
INSECTIVOROS								
Turdus migratorius	6	0.20 (0.20)	0.56 (0.18)	0.15 (0.08)	0.30 (0.15)	0.40 (0.24)		0.20 (0.20)
Contopus pertinax	5	1.00 (0.32)	0.20 (0.08)	0.30 (0.13)	0.20 (0.20)	0.20 (0.20)		
Myioborus pictus	5	1.40 (0.51)	0.84 (0.20)	0.45 (0.17)	1.50 (0.45)		0.20 (0.20)	
Piranga flava	5	0.60 (0.40)	0.08 (0.05)	0.15 (0.08)	0.10 (0.10)	0.40 (0.40)		
Colaptes auratus	4	0.40 (0.24)	0.04 (0.20)		0.10 (0.10)	0.20 (0.20)		
Pheucticus melanocephalus	4		0.24 (0.10)	0.05 (0.05)	0.20 (0.13)		1.00 (0.31)	
Campylorhynchus gularis	3	0.20 (0.20)	0.08 (0.08)	0.05 (0.05)				
Lepidocolaptes leucogaster	3		0.12 (0.07)	0.05 (0.05)	0.70 (0.26)			
Parus superciliosa	3		0.60 (0.21)	0.40 (0.21)	0.30 (0.15)			

Tabla 1.–Cantidad media de individuos por estación en siete tipos de vegetacion, y el numero total de hábitats en cuales se encontro cada especie—Continuada

GREMIO	# de hábitats	HABITAT Pino	Pino-encino	Encino	Encino-pino	Plant-acion	Matorral	Pastizal
INSECTIVORES—Continuada								
Sialia sialis	3		0.08 (0.08)		0.10 (0.10)			0.60 (0.60)
Trogon elegans	3	0.40 (0.24)	0.16 (0.08)		0.50 (0.22)			
Basileuterus rufifrons	2		0.08 (0.06)	0.10 (0.10)				
Empidonax species	2		0.08 (0.08)	0.10 (0.10)				
Ergaticus ruber	2		0.12 (0.09)	0.05 (0.05)				
Hirundo rustica	2					1.00 (1.00)	1.80 (0.97)	
Mimus polyglottos	2		0.12 (0.09)		0.20 (0.13)			
Myioborus species	2		0.04 (0.04)				0.20 (0.20)	
Myioborus miniatus	2		0.32 (0.11)	0.25 (0.12)				
Parus sclateri	2		0.28 (0.24)	0.40 (0.31)				
Psaltriparus minimus	2		0.28 (0.28)				0.40 (0.40)	
Vireo species	2		0.12 (0.33)	0.25 (0.20)				
Vireo huttoni	2			0.05 (0.05)			0.20 (0.20)	
Xenotriccus mexicanus	2		0.08 (0.08)	0.05 (0.05)				
Agelaius phoeniceus	1							0.40 (0.24)
Atlapetes virenticeps	1		0.08 (0.08)					
Certhia americana	1			0.05 (0.05)				
Dendroica graciae	1	0.20 (0.20)						
Empidonax affinis	1			0.05 (0.05)				
Empidonax difficilis	1			0.05 (0.05)				
Icterus parisorum	1							0.20 (0.20)
Icteria virens	1						1.40 (0.24)	
Junco phaeonotus	1		0.12 (0.09)					
Lanius ludovicianus	1		0.04 (0.04)					
Melanerpes aurifrons	1						0.20 (0.20)	
Molothrus aeneus	1		0.04 (0.04)					

Tabla 1.–Cantidad media de individuos por estación en siete tipos de vegetacion, y el numero total de hábitats en cuales se encontro cada especie—Continuada

GREMIO	# de hábitats	HABITAT Pino	Pino-encino	Encino	Encino-pino	Plant-acion	Matorral	Pastizal
INSECTIVORES—Continuada								
Myiozetetes similis	1			0.05 (0.05)				
Myiarchus tuberculifer	1		0.04 (0.04)					
Passerina species	1			0.10 (0.10)				
Passerina versicolor	1			0.05 (0.05)				
Picoides villosus	1				0.10 (0.10)			
Pyrocephalus rubinus	1				0.10 (0.10)			
Sitta carolinensis	1		0.04 (0.04)					
Sturnella magna	1						0.20 (0.20)	
Stelgidopteryx serripennis	1		0.16 (0.09)					
Tachycineta thalassina	1					2.40 (0.40)		
Toxostoma curvirostre	1							0.40 (0.40)
NECTARIVOROS								
Hylocharis leucotis	2		0.08 (0.08)		0.50 (0.22)			
Amazilia beryllina	1			0.25 (0.18)				
Cynanthus latirostris	1			0.05 (0.05)				
Eugenes fulgens	1			0.05 (0.05)				
Lampornis species	1			0.05 (0.22)				
Lampornis clemenciae	1			0.10 (0.07)				
OMNIVOROS								
Corvus corax	4	0.40 (0.24)	0.20 (0.10)	0.05 (0.05)	0.90 (0.55)			
Melanotis caerulescens	1				0.20 (0.20)			
Melanerpes formicivorus	1		0.24 (0.12)					

Tabla 2.—Cantidad media (±SE) de individuos por estacion en sies gremios alimenticios entre siete hábitats, y análisis de la varianza de clasificación simple de abundancia entre los hábitats.

GREMIO	# de especies	HABITAT Pino	Pino-encino	Encino	Encino-pino	Plant-acion	Mato-rral	Pas-tizal	F	df	P
CARNIVOROS	3			0.05 (0.05)			0.60 (0.60)		2.24	6,67	0.05
FRUGIVOROS	6	0.20 (0.45)	1.04 (0.21)	1.20 (0.28)	0.80 (0.42)	1.00 (0.55)			1.72	6,67	0.13
GRANIVOROS	6	2.60 (0.40)	0.32 (0.15)	0.05 (0.05)	0.20 (0.20)	1.60 (0.40)	1.40 (0.24)		16.96	6,67	0.00
INSECTIVOROS	46	4.40 (1.12)	4.68 (0.39)	2.70 (0.48)	4.40 (0.88)	4.60 (0.93)	5.40 (0.87)	2.50 (0.87)	2.43	6,67	0.04
NECTARIVOROS	6		0.08 (0.08)	0.50 (0.22)	0.50 (0.22)				1.53	6,67	0.18
OMNIVOROS	3	0.40 (0.24)	0.44 (0.18)	0.05 (0.05)	1.10 (0.55)				2.12	6,67	0.06

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El proyecto de Manejo del Ecosistema de las Montañas Ouchita: Un estudio de caso sobre el vinculo entre investigacion y administracion

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Resumen.—El Proyecto de Manejo del Ecosistema de las Montañas Ouachita, es un esfuerzo conjunto de investigación, y administración diseñado para generar apoyo científico para el manejo del ecosistema en las Montañas del Interior de Arkansas y Oklahoma en los Estados Unidos de América. El programa de tres fases es un estudio sobre cómo tanto el personal de investigación como el de administración, pueden trabajar en colaboración para obtener la aceptación pública, innovaciones en el manejo y un ambiente de investigación productivo. El programa se destaca por las asociaciones entre científicos, administradores de tierras, grupos de consejo al público y el público en general. La investigación en sí se caracteriza por un enfoque interdisciplinario en el que muchos tópicos se estudian al mismo tiempo, a menudo usando las mismas parcelas de experimentación. Una clave importante del éxito has sido el poner los investigadores científicos y los administradores en el mismo sitio, lo cual promueve el acceso de los científicos a las operaciones de administración y el acceso de la administración a la pericia de la investigación.

INTRODUCCIÓN

El Proyecto de Manejo del Ecosistema de las Montañas Ouachita es un esfuerzo de múltiples agencias en investigación y administración. El proyecto está localizado en el Bosque Nacional de Ouachita en las montañas del interior del occidente de Arkansas y el oriente de Oklahoma. El proyecto se destaca por un programa de investigación de tres fases administrado a través del Servicio Forestal del Departamento de Agricultura de los Estados Unidos (USDA), específicamente por la Estación Experimental Southern Forest, y también incluye varios proyectos de demostración a gran escala y métodos innovadores del manejo forestal. El proyecto surgió junto con el énfasis sobre el manejo del ecosistema en el Servicio Forestal y es un estudio de casos que demuestra la manera en que los administradores de bosques nacionales pueden colaborar con científicos para asegurar que las prácticas de administración se basan en los mejores resultados de investigación disponibles.

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ENFOQUE EXPERIMENTAL

La pieza central del proyecto es el programa de investigación, cuyo objetivo de proveer apoyo científico para el manejo del ecosistema en las Montañas del Interior hasta el próximo siglo y en lo adelante. El programa de investigación está dividido en tres fases de escala creciente, diseñado para la flexibilidad y la innovación mientras que aprendemos más acerca del manejo del ecosistema.

Fase I - Arboledos de Demostración

En la Fase I, ya terminada, científicos y administradores instalaron proyectos para demostrar el manejo de arboledos en el campo para ilustrar la filosofía surgiente en el manejo del ecosistema. Estas demostraciones se diseñaron para mostrar alternativas a la tala y siembra—tales como cortes parciales de edad igual y de edad diferente, regeneración natural, preparación mínima del sitio, y retención a largo plazo de árboles de varias especies de la cubierta alta (figuras 1, 2). Estos arboledos de demostración son de un valor tremendo, ya que proveen a líderes del Servicio Forestal, a executivos políticos claves, y a ciudadanos de todas partes con una vista desde el bosque mismo de la filosofía surgiente y la aplicación práctica del manejo del ecosistema.

Fase II - Estudio Científico a Nivel de Arboledo

La Fase II es un estudio científico, reproducido e implementado operacionalmente, que consiste de 52 arboledos de 35 acres (13 tratamientos por cuatro bloques geográficos) diseñados para estudiar los efectos del corte parcial para regeneración natural al nivel del arboledo. La Fase II incluye la retención de árboles de varias especies de la cubierta alta (pinos y maderas duras retenidas después del corte para reproducción), preparación del sitio a baja intensidad y liberación (incluyendo una prueba sin preparación del sitio y sin liberación), y la retención indefinida de árboles restantes de la cubierta alta. Ahora en su primera temporada de crecimiento después del tratamiento, la Fase II contiene el trabajo de cerca de 60 investigadores científicos del Servicio Forestal, de universidades y de industria, organizada en siete grupos de investigación interdisciplinaria.

Fase III - Estudio científico a nivel de paisaje.

La Fase III está diseñada para estudiar el manejo del ecosistema a escalas que transcienden el arboledo individual, tales como divisorias de las aguas y paisaje. El objetivo de la Fase III es evaluar

Figura 1.—Un corte parcial de edad igual ilustra una alternativa a la tala y sembrado: una modificación del método de corte para reproducción, en el cual los pinos y las maderas duras son retenidos en la cubierta alta.

Figura 2.—Un corte parcial de edad diferente ilustra una alternativa a la tala y sembrado: una modificación del método de corte para reproducción con la selección de un solo árbol, en el cual los pinos y las maderas duras son retenidos en la cubierta alta.

la sostenibilidad del manejo del ecosistema comparándose paisajes con diferentes configuraciones forestales. De énfasis especial son los efectos acumulativos de las acciones de manejo en la estructura y función del ecosistema de gran escala, con especial énfasis en hidrología de cuencas, especies críticas de flora y fauna en tanto los sistemas terrestres como los acuáticos, y el contexto social de las acciones de manejo basadas en el paisaje.

ELEMENTOS CLAVES

Asociaciones

Se encuentran los científicos de la Estación Southern y el personal de enlace de bosques nacionales juntos en las oficinas centrales de investigación de la Oficina del Supervisor de los bosques nacionales. El personal de los bosques nacionales apoya la investigación directamente a través de decisiones de personal, análisis ambiental, presupuesto, y operaciones del distrito de los guardabosques en los arboledos experimentales. El equipo de investigación incluye más de 60 científicos de nueve unidades de investigación del Servicio Forestal y más de una docena de universidades, coordinados por los líderes del equipo de investigación y los administradores de las estaciones.

El tener miembros del equipo con diferentes áreas de interés es también un elemento importante de la investigación. El Comité Consultivo para el Manejo del Ecosistema del Bosque Nacional Ouachita desempeñó un papel en hacer que los investigadores enfoquen sus estudios en ecología, recursos, y el contexto social. La participación de los ciudadanos es esencial en la planificación de una investigación como ésta; tanto investigadores como administradores han sido instruidos durante extensas discusiones con una gran variedad de grupos con intereses específicos e individuos. Finalmente, un cliente tradicional, la industria forestal, continúa desempeñando un papel activo con sus consejos sobre diseños experimentales e intereses de la industria.

Investigación Interdisciplinaria

Siete grupos de investigación comprenden la Fase II que trata con: silvicultura, fauna silvestre, diversidad de plantas de la cubierta baja, calidad de suelos y del agua, artrópodos y diversidad micróbica, explotación forestal—economía, y calidad visual. Cinco grupos de investigación comprenden la Fase III que trata con: ecología vegetal, ecología de la fauna silvestre, hidrología, ecología acuática, y ciencia social. Estos grupos, en conjunto con los líderes de investigación, planean los estudios interdisciplinarios usando los mismos arboledos y divisorias de las aguas; también comparten datos y proveen un método experimental más completo que fuera posible con el enfoque tradicional de "un científico, un estudio."

Intercambio mutuo entre Investigación y Administración

Entre los beneficios inesperados está el que los científicos y los administradores trabajan estrechamente cada día. Esto les da oportunidades para que cada uno aprenda del otro. Por ejemplo, todos los 52 arboledos de la Fase II fueron marcados en 1992 por el personal de distritos de guardabosques del Bosque Nacional Ouachita para una recolección experimental, usando pautas proporcionadas por los investigadores. Muchas de estas normas de marca se usan ahora regularmente en los distritos de guardabosques. Además, los científicos participan regularmente en estudios del programa de bosques nacionales y en discusiones sobre políticas. Esta influencia recíproca entre los científicos y los administradores conduce a un proceso de manejo adaptivo en el cual la información obtenida por la investigación se aplica a las prácticas de administración y a las operaciones en el campo.

Los científicos investigadores también han aprendido de los administradores. Los planes de investigación se ajustaron constantemente para reflejar en forma mejor las condiciones reales bajo las cuales se hacen las decisiones administrativas y, especialmente para hacer cumplir la investigación con las leyes y los reglamentos necesarios que gobiernan el manejo los bosques nacionales.

A medida que los estudios se desarrollan, se planea producir resultados a través de modelos de computadora y programas de educación continua dirigidos a los administradores y equipos de campo de los bosques nacionales. Será importante

para los investigadores y administradores colaborar en esta etapa también para que los resultados de la investigación tengan sentido y puedan ser aplicados en los bosques.

EL FUTURO

El Proyecto de Manejo del Ecosistema de las Montañas Ouachita proporciona un estudio de casos acerca de los beneficios que resultan cuando científicos y administradores trabajan en cooperación hacia un objetivo común. Las demostraciones de la Fase I han sido extremadamente útiles para visualizar alternativas de manejo. Los experimentos a nivel de arboledo de la Fase II darán resultados detallados durante la próxima década que ayudarán a los administradores a aplicar estas alternatives en una manera confiable de un punto de vista científico, y generarán resultados para la próxima década. El estudio a nivel del paisaje de la Fase III deberá producir resultados detallados en una manera similar, y se espera que esto ocurre en los dos próximas décadas. En combinación, este enfoque de tres fases ilustra un método exitoso de desarrollar apoyo científico y aceptación social para el manejo del ecosistema de las Montañas Ouachita.

Sedimentos derivados de los caminos en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México

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Resumen.—El objetivo de este trabajo fue examinar los caminos como una fuente de sedimentos en la cuenca del arroyo El Carrizal, ubicada en la Sierra de Tapalpa, municipio de Tapalpa, Jalisco, México.

La red de caminos del área de estudio la conforman: 1) caminos principales sobre el perímetro de la cuenca del arroyo El Carrizal y a lo largo del canal del arroyo principal; y 2) Pequeños caminos de acceso temporal, que se unen al sistema principal. La superfície de los caminos tiene fragmentos de roca y grava. Hay una zona con cárcavas activas dentro de la cuenca del arroyo El Carrizal, que es riolítica altamente erosiva, la cual está ubicada a lo largo del camino perimetral izquierdo. Este sistema de cárcavas es un ejemplo donde el suelo y la geología (riolita intemperizada) interactúan con las actividades de manejo (caminos), para producir zonas de alto riesgo de erosión. La estimación de los volúmenes de sedimentos se obtuvo mediante levantamientos con nivel, mediciones directas de áreas erosionadas, trampas de sedimento y presas de escombro. Se concluye que: 1) El carrizal es una cuenca cuya condición básica es buena; 2) Los caminos son la fuente principal de sedimento que llega a los arroyos (algunas cárcavas longitudinales de los caminos se han erosionado rapidamente, perdiendo 300 metros cúbicos de suelo en 5 años); 3) Diversos métodos de bajo costo como bermas, trampas de sedimento, construcción de presas, cunetas y topes de base ancha, pueden usarse para prevenir la erosión excesiva en los caminos y conservar la calidad del arroyo El Carrizal.

INTRODUCCIÓN

Un producto muy importante derivado del manejo sostenible del ecosistema forestal es el flujo contínuo de agua de buena calidad. Este recurso es importante para el consumo humano, la agricultura y la recreación. La demanda de agua crece contínuamente al aumentar la población, la agricultura intensiva y al expandirse las áreas fabriles. La permanencia de corrientes de agua de buena calidad es necesaria para mantener saludables las poblaciones de biota terrestre y acuática. Amén de que la cantidad y calidad del flujo de agua es un componente crucial para el manejo sostenible de los bosques.

La condición de la cuenca, es un concepto usado para evaluar la capacidad relativa de la misma para recibir precipitación y entregar al ambiente el flujo en los arroyos y a través de la recarga de acuíferos subterráneos. Una cuenca en "buena" condición tiene: 1) un flujo de agua contínuo que forma un arroyo perenne; 2) Agua de buena calidad; y 3) Transporte mínimo de sedimentos.

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Una cuenca en condición "pobre" tiene: 1) Un flujo del agua impetuoso pero efímero después de las tormentas, 2) Calidad del agua baja; y 3) Gran cantidad de sedimentos.

La mayoría de los bosques bien manejados tienen cuencas en buena condición, sin embargo, aspectos importantes del manejo sostenible del bosque son, el conocimiento de las zonas delicadas y la identificación de las actividades que pueden causar el deterioro rápido de una cuenca en buenas condiciones.

Los caminos constituyen el mayor peligro de erosión, ya que pueden deteriorar rápidamente la condición de una cuenca y la calidad del agua; siendo las áreas con suelos o rocas desnudos, la fuente principal de escurrimiento superficial y sedimentos, que pueden ingresar fácilmente en los arroyos.

El término "caminos" incluye brechas temporales de acceso y extracción de madera, así como el sistema de transporte principal y secundario. En las brechas temporales, la mayor erosión ocurre entre los dos y cuatro años a partir del disturbio inicial. Los caminos permanentes son fuentes contínuas de sedimento y la cantidad de este depende de varios factores.

El volumen de sedimentos producidos por un camino está en función del diseño, ubicación, construcción, superficie y materiales de relleno, uso y mantenimiento; interactúando con la topografía, la hidrología y el clima. En gran parte de los Estados Unidos de América y del mundo, la construcción de caminos para la silvicultura, provoca la mayor producción de sedimentos (Brown, 1972). La superfície erosionada en caminos forestales mal construidos y con bajo mantenimiento, puede exceder la reportada para áreas agrícolas severamente erosionadas (Megahan, 1986). Consecuentemente se han mejorado substancialmente las prácticas de manejo para la construcción y mantenimiento de caminos (Burns *et al.*, 1995; Hynson *et al.*, 1982; North Carolina Division of Forest Resources, 1989; Ontario Ministry of Natural Resources, 1988; Rothwell, 1978; Swift, 1985).

El proceso para minimizar la producción de sedimentos en los caminos, se inicia con un diseño apropiado, un buen programa de construcción y una buena supervisión ingenieril (Larse,1971; Swift, 1988). El propósito de estas prácticas es minimizar la pérdida del suelo por el impacto de las gotas de lluvia; el levantamiento del camino por congelación, sequía o desmoronamiento de bordes; prevenir deslizamientos del suelo aguas abajo o movimientos en masa; y reducir la erosión del manto rocoso del camino. Algunos factores del diseño de caminos para reducir sedimentos se presentan en el Cuadro 1.

King (1984), documentó que una buena técnica de construcción de caminos puede disminuir la producción de sedimentos entre el 19 y el 156%. por otra parte la selección correcta de materiales

Cuadro 1. El control de la erosión durante el diseño, construcción, uso y mantenimiento de los caminos forestales.

1. Técnicas de Construcción y Diseño.
   a) Planeación para evitar la degradación en la estación de lluvias.
   b) Diseñar mejor los caminos para minimizar el cruce de arroyos.
   c) Mantener una distancia adecuada de amortiguamiento respecto al cauce.
   d) Construir barreras o topes e instalar alcantarillas para abatir el flujo.
   e) Minimizar la excavación y movimiento lateral de materiales.
   f) Diseñar derivaciones de base ancha o de corona para el drenaje del camino.
   g) Instalar retenes, trampas, bermas, alcantarillas y jorobas para el desagüe.

2. Medidas de Control de Movimiento de Sedimento Durante el Uso.
   a) Siembra y establecimiento de vegetación nativa, pastos y leguminosas.
   b) Construcción de barreras tipo cepillo.
   c) Instalación de cerca o defensa para atrapar el sedimento.
   d) Capa de piedra como revestimiento.
   e) Restos de paja húmeda y fragmentos de desechos de madera.
   f) Roca-grava que emerge en áreas en peligro de erosión elevada.
   g) Materia orgánica y vegetación filtrante en las fajas de amortiguamiento.

3. Procedimientos de mantenimiento de Caminos.
   a) Nivelación de la superficie diseñada para el drenaje.
   b) Limpiar zanjas, alcantarillas, trampas de sedimento, etc.
   c) Remozar secciones deterioradas.
   d) Cerrar o restringir el acceso a caminos poco usados.
   e) Construir barras para desvío del agua.
   f) Inspección periódica de caminos abiertos y cerrados.

para la superficie de los caminos, reduce los sedimentos entre el 70 y el 99% (Kochenderfer y Helvey 1984; Megahan 1987 y Swift, 1984).

Algunas técnicas, medidas y procedimientos para el control de la erosión en los sistemas de caminos, se presentan en el Cuadro 1. El movimiento del suelo fuera del camino puede reducirse de 24 a 99% con las técnicas citadas (Megahan, 1980 y 1987; Swift, 1986). los costos de materiales y mano de obra asociados con estos métodos son muy variables, dependiendo del tipo y disponibilidad del material, de los requerimientos de maquinária y de la mano de obra necesaria.

Burns *et al.* (1955), describieron diversas técnicas de bajo costo para controlar el movimiento de sedimentos, e indican que con el uso de cunetas, trampas de sedimento, apertura de bermas, desviaciones del agua en las pendientes, las jorobas (topes de base ancha) y las atarjeas de desfogue, se evita que alrededor del 75 % del sedimento asociado con los caminos llegue a los arroyos.

El mantenimiento de los caminos es muy importante para mantener bajo el nivel de erosión (Cuadro 1). Los caminos con poco mantenimiento desarrollan surcos en los sitios de la rodada, que pueden canalizar el escurrimiento a lo largo de su superficie, en vez de llevarlo hacia afuera de ella. Las zanjas, alcantarillas, trampas y desviaciones, rebasadas por los sedimentos, no pueden funcionar adecuadamente, de manera que su utilidad en el control de sedimentos se vuelve despreciable y de hecho pueden agravar la erosión.

El objetivo de este trabajo fue examinar los caminos como una fuente de sedimentos para el arroyo El Carrizal, además, se hacen recomendaciones para contribuír a la sostenibilidad de producción de agua de buena calidad a través del manejo múltiple de los recursos.

MÉTODOS

El Área de Estudio

La cuenca del arroyo El Carrizal está ubicada en el Eje Neovolcánico Transmexicano, en la Sierra de Tapalpa, municipio de Tapalpa, Jalisco, México (Figura 1). La cuenca comprende 1,220.4 Ha, de las cuales 762.7 Ha confluyen al vertedor de aforo construído en 1994 (Figura 2).

El tipo de vegetación dominante es bosque templado, con mezcla de *Pinus* y *Quercus*, las especies arbóreas dominantes son *Pinus michoacana*, *P. douglasiana*, *Quercus resinosa*, *Q. rugosa* y *Q. obtusata* (Gómez-Tagle y Chávez, 1986); en las cañadas la vegetación corresponde a bosque mesófilo de montaña y las especies leñosas más conspicuas son *Rhamnus mucronata*, *Viburnum stellatum*, *Phoebe arsenei*, *Salix bonplandiana*, *Salix oxylepis*, *Fraxinus* sp., *Prunus bachybotrya*, *Prunus serotina capuli*, *Cornus excelsa* y *Alnus* sp. El número de estratos es variable y usualmente involucra, además del arbóreo, arbustos, pastos y hierbas (Madrigal-Sánchez *et al.*, 1955).

Los bosques en esta región de México han sido significativamente alterados desde la colonización española a partir del año 1570. El bosque se ha cosechado, pastoreado e incendiado periódicamente durante, aproximadamente, 400 años. Hay registros de dos grandes incendios que afectaron la parte superior de la cuenca del arroyo El Carrizal, uno alrededor del año 1900 y el otro en 1950.

El rango de altidud es de 2,000 a 2,420 msnm. La precipitación media anual es 903 mm, con una sola temporada de lluvias, entre junio y octubre; el mes más húmedo es julio con 170 mm y el más seco febrero con 7 mm. El régimen de flujo del arroyo es perenne (Baker *et al.*, 1995).

La geología de la cuenca es variada y es preponderante la ígnea del Cenozoico con erupciones volcánicas de 8 millones de años. La mineralogía primaria incluye desde basalto rico en fierro y

Figura 1. Localización de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

olivinos, hasta riolita y tobas riolíticas con altos niveles de sílice; la litología dominante es basáltica (Figura 3). Las partes bajas de la cuenca del arroyo El Carrizal son de naturaleza aluvial y se emplean en la agricultura, también hay una pequeña zona con mezcla de pizarras y areniscas, en el límite oriental de la cuenca. Estas formaciones sedimentarias quedaron sepultadas por la actividad volcánica del Cenozoico. El patrón de drenaje de la cuenca del arroyo El Carrizal es dentrítico, con escurrimientos intermitentes de primero y segundo orden.

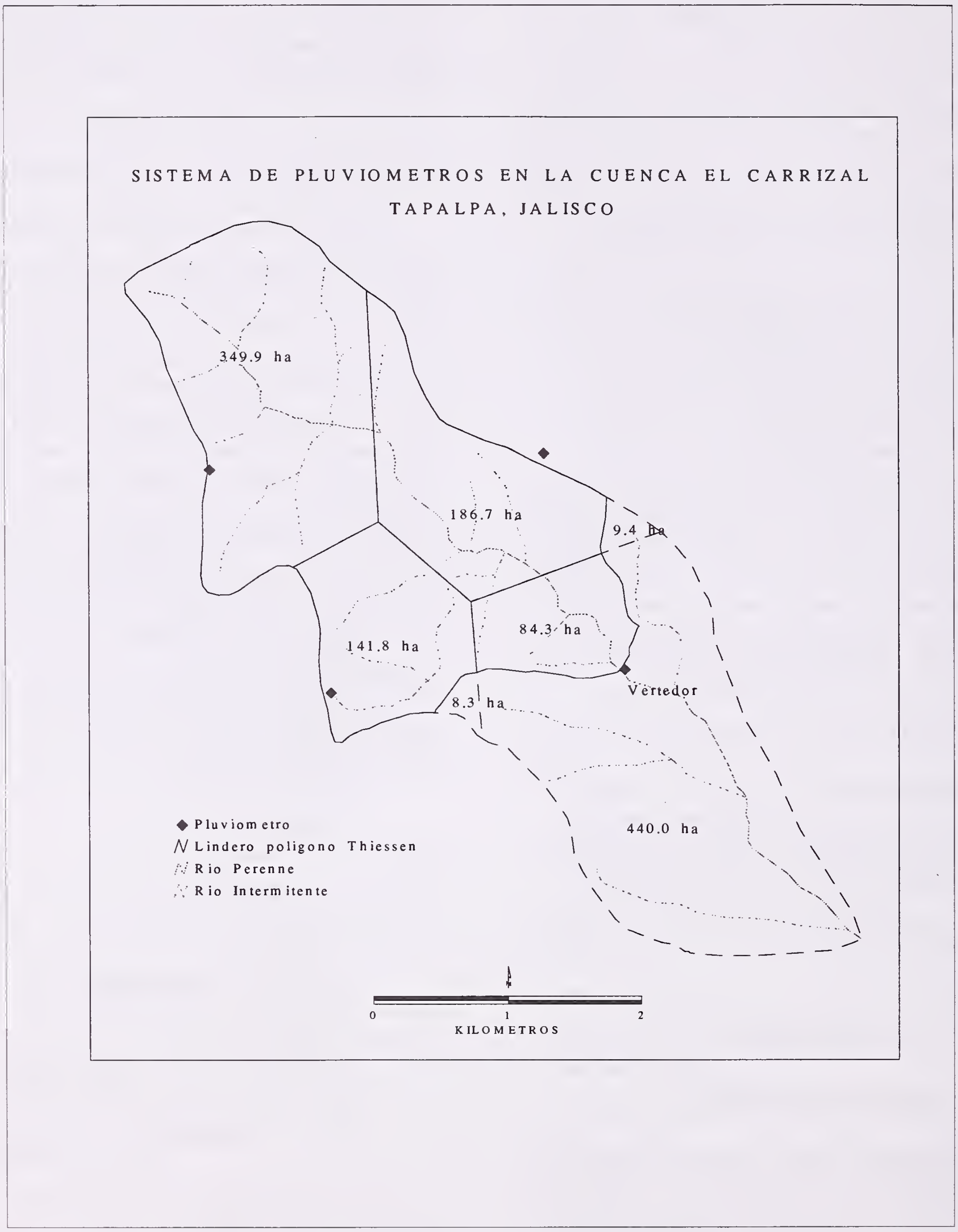

Figura 2. Ubicación de pluviógrafos, medidor de flujo, red hidrológica y polígonos de Thiessen en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

Los suelos son principalmente regosoles (andicos) sobre saprolita profundamente intemperizada. (Figura 4) (Gómez-tagle y Chávez, 1986). Los feozem y cambisoles ocurren principalmente en las zonas con menor elevación, los luvisoles son subyacentes a los regosoles y generalmente quedan expuestos por erosión.

Los regosoles están altamente erosionados pero profundamente intemperizados debido a que en su mayor parte la roca madre es toba, la saprolita

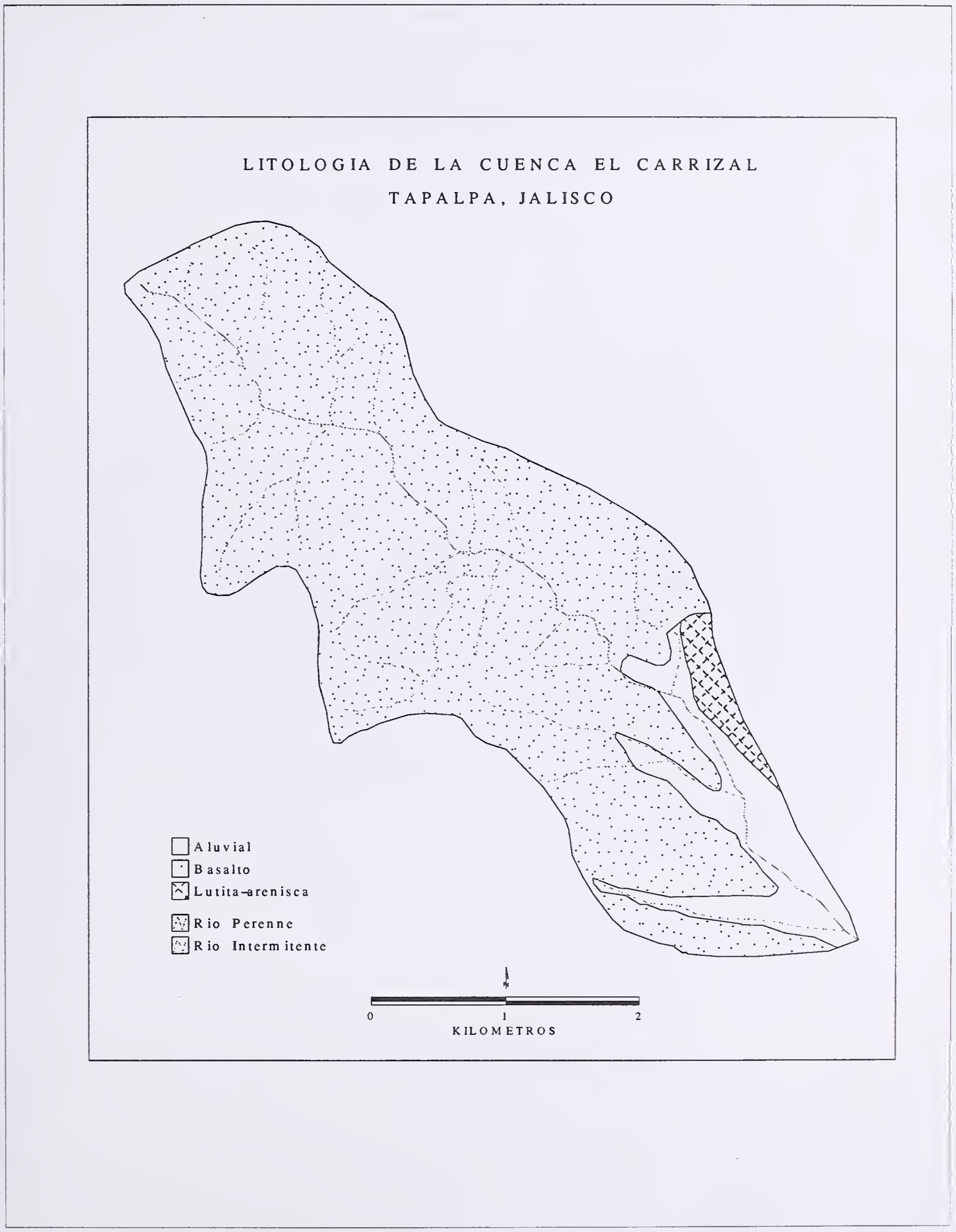

Figura 3. Mapa Litológico de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

isovolumétricamente intemperizada se extiende por más de 4 m de profundidad bajo el *solum* (Figura 5). Las áreas con baja capacidad de infiltración debido al manto rocoso o por presencia de duripanes, son relativamente pequeñas dentro de la zona arbolada de la cuenca del arroyo El Carrizal.

La naturaleza inalterada del piso del bosque a lo largo de la cuenca del arroyo El carrizal, con saprolita y suelos profundos, un mínimo de áreas

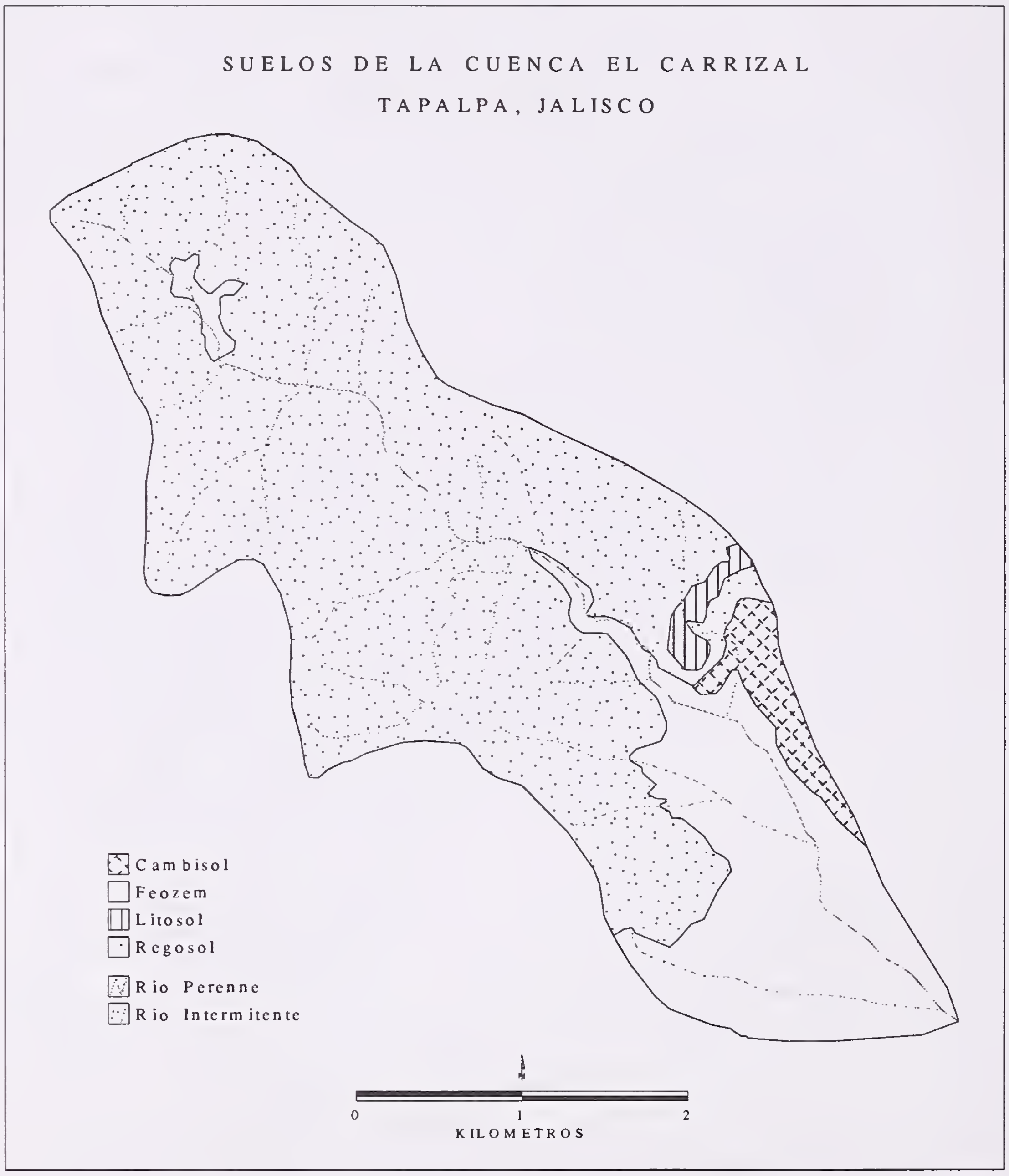

Figura 4. Mapa Edafológico (FAO) de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

erosionadas, el manto rocoso descubierto o con superfícies impermeables, hacen que la cuenca tenga una excelente condición. La presencia de roca intemperizada (saprolita) bajo el suelo, también contribuye a la buena condición de la cuenca.

Durante el proceso de intemperización hay lixiviación de minerales primarios que crea espacios vacíos al no haber pérdida de volumen (intemperismo isovolumétrico). Este proceso crea un enorme almacén para la precipitación que se

Figura 5. Mapa de Fases de Suelo de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

infiltra en el suelo; el cual, a su vez, alimenta lo que en hidrología se conoce como el flujo base (baseflow) que produce la corriente perenne del arroyo, que como ya se mencionó es un indicador de la buena condición de la cuenca.

Red de Caminos

La red de caminos consta de: 1) caminos principales en el perímetro de la cuenca del arroyo El Carrizal y a lo largo del canal principal de arroyo; 2) caminos de acceso menores, temporales, vinculados al sistema principal; y 3) brechas de extracción forestal. Sobre la superfície de los caminos se extiende grava para proteger el suelo. Se hizo una inspección de los caminos de la cuenca del arroyo El Carrizal, se midió la longitud total por medio de un odómetro de rueda y se clasificaron en "bueno", "medio" o "malo", dependiendo de la condición de: 1) materiales superficiales, 2) cantidad de superfície acanalada por la rodada; y 3) profundidad de la rodada.

Los Sistemas de Cárcavas

Se hizo un reconocimiento completo de la cuenca para ubicar las cárcavas activas dentro de la cuenca del arroyo El Carrizal, que corre a lo largo del camino perimetral del lado izquierdo. Es un área con toba riolítica altamente erodible y constituye un ejemplo de situaciones donde la litología y los suelos interactúan con las actividades de manejo produciendo zonas con alto riesgo de erosión. Una sección del camino perimetral izquierdo (actualmente abandonado), descarga su escurrimiento superficial en una zona altamente erosiva de toba riolítica intemperizada. La erosión contínua no solamente transporta mucho sedimento, sino también amenaza con socavar el camino actual.

Otro sistema de cárcavas, de edad desconocida, se ubicó en el camino perimetral del lado derecho, el cual ha sido estabilizado por la vegetación del bosque. El camino adyacente a este sistema de cárcavas experimenta actualmente erosión de moderada a severa. Otra cárcava se ha venido desarrollando durante los últimos cinco años a lo largo de la porción inferior del camino de acceso del área ribereña (camino hacia Las Maquinitas).

El Control de Erosión

Diversas técnicas para controlar el movimiento de sedimentos han sido desarrolladas en la cuenca del arroyo El Carrizal durante el último año. A lo largo de los caminos, se construyeron salidas de zanja, trampas de sedimento, jorobas, presas de piedra y diques de rama (Burns *et al.*, 1995). En algunas de las cárcavas más importantes se construyeron presas de rama y presas de piedra.

En el pasado, en los sitios bajos del camino que cruzan el arroyo, se construyeron (con basalto columnar) varios vados de piedra acomodada; éstos han sido eficientes para atrapar el sedimento, de 2 a 3 m en varias décadas y se han ido elevando, por la adición de piedras, conforme más sedimentos han sido retenidos. Se construyeron dos nuevos vados cerca de las minas de roca sobre el cauce del arroyo El Carrizal y en sitios donde la erosión era significativa.

Mediciones de Erosión

La estimación de los volúmenes de sedimento se obtuvo por medio de levantamientos con nivel, tomando datos de largo, ancho y profundidad de las zanjas. En el camino perimetral izquierdo, se tomaron medidas directas de las dimensiones de las cárcavas en el año de 1994. Los levantamientos con nivel se hicieron en la parte inferior del camino general de acceso. La estimación de volumen de erosión se convirtió a masa, usando una densidad promedio de 2,000 Kg/m^3 (Hooke, 1994).

RESULTADOS Y DISCUSIÓN

Caminos

La Red.— El sistema de caminos, excluyendo las brechas de extracción de productos forestales, dentro del límite, que incluye el área arbolada de la cuenca del arroyo El Carrizal y la cuenca de La Hacienda adyacente, suma 54.5 Km (Figura 6 y Cuadro 2). Considerando el ancho promedio de los caminos, esto representa casi el 2% de la superficie forestal de ambas cuencas. Con excepción de 3 minas pequeñas de roca y la erosión de la rivera, el 2% del área terrestre es responsable del volumen

de sedimento producido en la cuenca del arroyo El Carrizal. Las contribuciones de sedimento de las minas y orillas de los cauces no se han medido. La producción de sedimento por procesos geomorfológicos, tales como los ajustes del canal y la erosión de la rivera es de 110 a 220 Kg/Ha/año para las regiones húmedas.

Erosión en el camino de la parte alta.— A lo largo del camino del lindero derecho, en el predio Pegueros, hay dos secciones erosionadas con

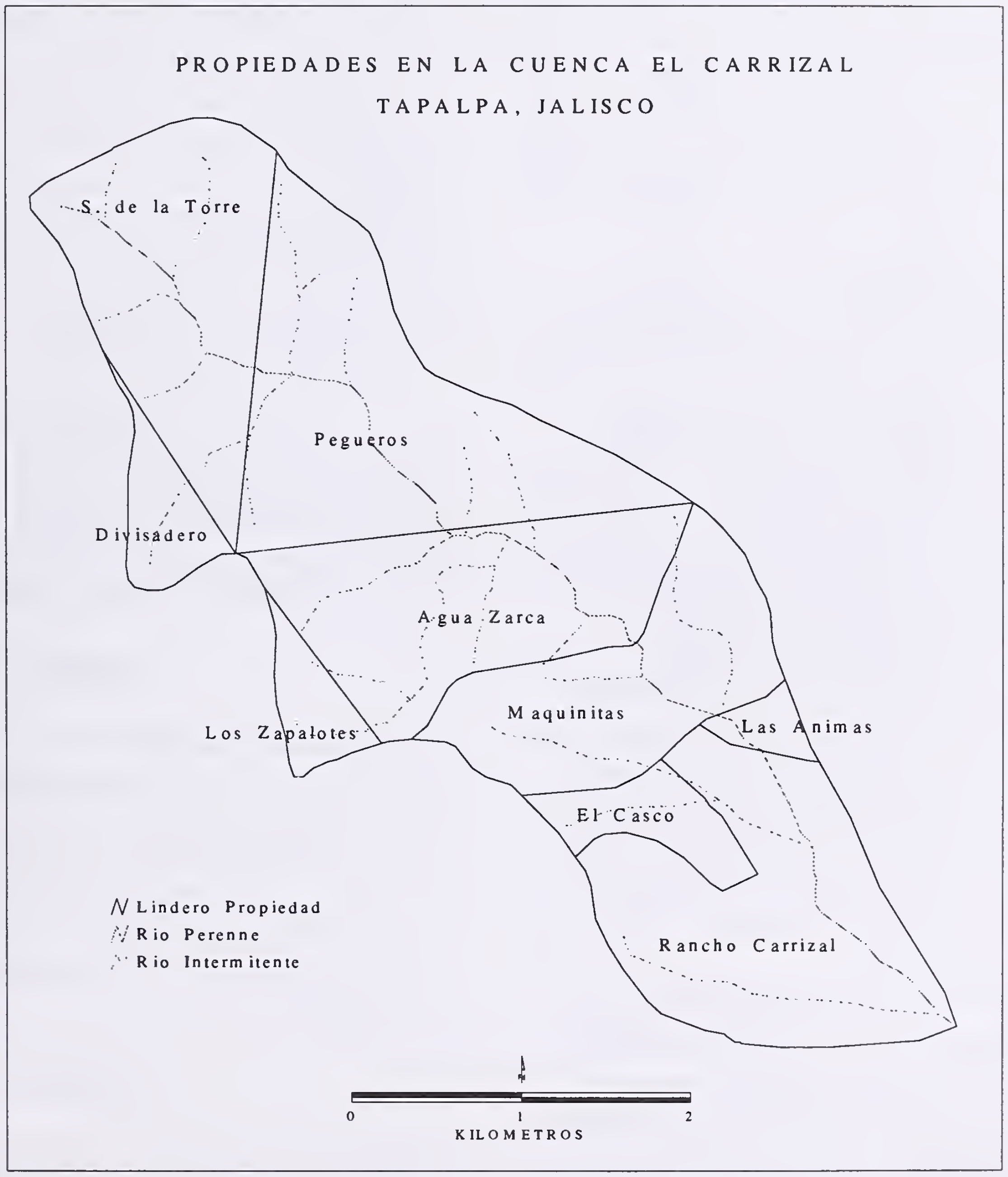

Figura 6. Mapa predial de la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

Cuadro 2. Longitud de los caminos forestales principales por predios en las cuencas del arroyo El Carrizal y La Hacienda, Tapalpa, Jalisco, México.

PREDIO	LONGITUD DEL CAMINO (m)
El Carrizal	
1. Pegueros	8,866
2. Agua Zarca	9,018
3. Maquinitas	2,715
4. El Casco	759
5. Las Animas	798
El Carrizal y La Hacienda	
6. Divisadero	9,263
7. Los Zapalotes	11,107
La Hacienda	
8. Ojo de Agua	2,999
9. La Pitilla	3,551
10. Otro camino de acceso	5,460
Longitud Total de Los Caminos	**54,536**

canales en el sentido de la pendiente; las secciones están separadas por el banco a nivel. El camino corre justamente en sentido ascendente y paralelo al sistema de cárcavas estabilizadas que se discutió en la metodología. La sección inferior es de 180 m de largo; se desconoce su edad precisa, pero es probable que tenga menos de 10 años. El levantamiento se hizo en febrero de 1994. Aproximádamente 1,400 m^3 de suelo (2,800 Mg o toneladas métricas) han salido de esta sección por erosión. La suma de las pérdidas de sedimento para ambas secciones está entre 5,000 y 6,000 Mg. La mayor parte del sedimento parece haber sido depositado en bancos gradiente abajo, siguiendo las depresiones del camino erosionado, en vez de correr por arroyos efímeros.

Erosión del camino en la parte inferior.— Se desarrolló una cárcava larga en toda la zanja de drenaje del camino ascendente que va desde el Rancho Carrizal al predio Maquinitas. Se presume que ésta se formó rápidamente, en los últimos 5 años, sobre la cuneta, en una pendiente descendente de aproximádamente 650 m. La porción inferior permanece activa, ampliando la cárcava, mientras que en la parte superior aún se puede reconocer la cuneta. El levantamiento con nivel hecho en febrero de 1994, muestra que la erosión implica la pérdida de alrededor de 300 m^3 (600 Mg) de suelo. La mayoría de estos materiales fueron depositados sobre los pastizales del Rancho El Carrizal.

Durante las tormentas, gran cantidad de sedimento suspendido fluye fuera de este sistema de cárcavas.

Cárcavas

En el área severamente erosionada a lo largo del camino del lindero izquierdo, se instalaron dos tipos de presas de control de sedimentos para determinar su función y la cantidad de los sedimentos retenidos. Se construyeron seis presas de control en los ramales externos, a lo largo de una sección de control de 145 m de cárcavas activas. Al cabo de tres meses, durante la temporada de lluvias, las presas acumularon 1.46 m^3 (aproximádamente 2.9 Mg) de sedimentos. En las cárcavas más grandes (de hasta 5m de profundidad), se construyeron cuatro presas de control de sedimentos con pequeños troncos, a lo largo de una cárcava de 297 m. En el mismo período de tres meses acumularon 7.49 m^3 de sedimento (alrededor de 15 Mg).

Estos resultados preliminares muestran las cantidades de sedimento erosionado de la superficie de los caminos. También indican la cantidad de sedimento que puede ser atrapado y estabilizado mediante técnicas y estructuras de costo relativamente bajo, esto es discutido más detalladamente por Burns *et al.* (1995).

Minas

Hasta el momento no se cuenta con una buena estimación de los sedimentos de las tres minas de roca a cielo abierto en el área de estudio. Una de las dos minas grandes se ubica justamente junto al cauce del arroyo perenne El Carrizal; la otra mina está en el límite de la rama derecha del camino, aproximádamente a 1 Km del cauce del arroyo principal.

Vados

Hay varios vados construídos con basalto columnar obtenido de la cuenca del arroyo El Carrizal. Estos vados son barreras permeables, cuya función es proveer de una superfície de bajo costo funcional y duradera, para el paso de los vehículos y retención de sedimentos. Los vados más antiguos han acumulado de 2 a 3 m de sedimentos durante varias décadas. En 1994 y con la finalidad de retener los sedientos procedentes de las minas, se construyeron dos más, el primero

sobre el arroyo principal y el otro en la base de una pequeña mina de roca donde los sedimentos eran conducidos directamente hacia el arroyo. En los vados se hace la valoración contínua de la retención de sedimentos; el que está cerca de la mina acumuló 1.44 metros cúbicos en tres meses.

Comparación

A manera de referencia en el Cuadro 3 se muestran algunos valores de pérdida de sedimentos (Neary y Hornbeck, 1994). los valores geológicos de erosión son representativos de grandes extensiones (> 10,000 Ha), los demás son valores tomados de cuencas (< 1,000 Ha). Tanto en el oriente como en el occidente de los Estados Unidos de América, las pérdidas de sedimento de cuencas no alteradas son notablemente similares, hay algunas excepciones relacionadas con la geología local y los procesos geomorfólogicos. Según el análisis de Hooke (1994), las pérdidas más grandes se vinculan a las actividades humanas.

El arroyo El Carrizal, tiene un componente bajo de carga del cauce y un componente alto de sedimentos suspendidos. Por arriba del vertedor la cuenca permanece relativamente estable y poco alterada, por ello se seleccionó el rango medio de producción de sedimentos para cuencas con bosque no alterado, para calcular las pérdidas en los cauces de la cuenca del arroyo El carrizal (Cuadro 4). Esto produjo una estimación de 232.5 Mg/año para 762.7 Ha. La otra estimación de

Cuadro 3. Comparaciones de pérdida de sedimentos.

FUENTES	PÉRDIDAS	(Mg/HA/AÑO)
1. Erosión geológica en EUA:	Baja	0.6
	Alta	15.0
2. Bosques inalterados del Este de EUA:	Baja	< 0.1
	Alta	0.6
3. Bosques inalterados del Oeste de EUA:	Baja	< 0.1
	Alta	0.5
4. Camino forestal en construcción en EUA:	140.0	
5. EUA: Tolerancia máxima en tierras de cultivo	11.2	
Pérdida en terrenos agrícolas	Alta	13.0
6. EUA: Sitio con preparación forestal intensiva	15.0	
7. China: Forestal sin corte en Hong Kong	2.0	
Forestal con cortas de aclareo en Hong Kong	97.0	
8. Nueva Zelanda: Forestal sin corte en Westland:	0.4	
Forestal con cortas de aclareo en Westland	3.4	

Fuente: Neary y Hornbeck (1994).

Cuadro 4. Comparación de pérdida de sedimentos en la cuenca del arroyo El Carrizal, Tapalpa, Jalisco, México.

FUENTE	PÉRDIDA (Mg)	SUPERFICIE (Ha)	PERÍODO
1. Cauces de el arroyo El Carrizal	232.5	762.7	1 año
2. Camino perimetral derecho	5,600.0	0.5	Desconocido
3. Camino inferior	600.0	0.3	5 años
4. Camino perimetral izquierdo	2.9	0.1	3 meses
5. Cárcavas del límite izquierdo	15.0	0.5	3 meses

pérdida de sedimento ilustra claramente un aspecto importante documentado en muchos otros lugares. Las áreas relativamente pequeñas del paisaje asociadas con los caminos o las cárcavas iniciadas por caminos, produjeron grandes e inusuales volúmenes de sedimentos. La cantidad de sedimento perdido por 0.5 Ha del camino perimetral derecho de la cuenca es equivalente a las pérdidas del cauce total de la cuenca en 24 años. Entonces, la clave para mantener la calidad del agua en la cuenca de el arroyo El Carrizal, es el control de la erosión en los caminos.

CONCLUSIONES

Las conclusiones de este estudio son: 1) Actualmente la cuenca del arroyo El Carrizal tiene una condición básica buena, 2) los caminos y las cárcavas originadas en los caminos son las fuentes principales de sedimentos en la cuenca; y 3) diversas técnicas de bajo costo pueden utilizarse para retener y estabilizar el sedimento antes de que llegue a los cauces de los arroyos.

Es recomendable que para mantener la calidad del agua en el arroyo El Carrizal, en el futuro debe prestarse mayor atención al diseño, construcción, mantenimiento y restauración de los caminos para minimizar la erosión y transporte de sedimentos a los canales del arroyo.

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Centro para la utilizacion de los productos de ecosistemas forestales

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El Centro para la Utilización de Productos de los Ecosistemas Forestales, se está desarrollando a través de un esfuerzo conjunto entre el INIFAP el USDA-FS y la Universidad Estatal de lo Colorado. Dentro del plan a 10 años se propone la meta de desarrollar la infraestructura material y humana, para lograr que este Centro constituya el sistema de soporte más avanzado al servicio del sector forestal. El Centro apoyará programas de investigación, capacitación e inovación tecnológica. Actividades relacionadas al desarrollo económico serán de caracter fundamental en el Centro. Asimismo, comprenderá el espectro de productos maderables (ejemplo: madera en rollo, aserrada chapa, etc.) y de productos no maderables disponibles en los ecosistemas forestales. El Centro reconoce que el desarrollo sostenido del bosque y una base tecnológica congruente con el recurso y sociedad, proveerá el ambiente necesario para crear una economia forestal solida, la cual a su vez producirá los beneficios económicos que tendrán efectos positivos en la sociedad y el medio ambiente.

La investigación básica y aplicada sera desarrollada a traves de la coolaboracion entre la industria, el gobierno y la universidad. La ejecucion de los proyectos de investigacion se realizará en base a convenios entre los gobiernos de E.U. y México. El Centro definirá una agenda de investigacion que comprenda el rango de ecosistemas forestales de Mexico.

En la próxima decada, el Centro planea proveer aproximadamente 250 profesionistas mexicanos con educación a nivel maestría y doctorado. Los estudiantes de maestría recibirán cursos técnicos a través de expertos extrajeros, en base a un programa desarrollado en la Universidad Estatal de Colorado, y ofrecido a través de universidades mexicanas. Los programas de doctorado se realizarán a través de universidades extranjeras con programas reconocidos en las disciplinas apropiadas.

Un programa extensivo de divulgación es propuesto a traves del Centro, incluyendo cursos de capacitación, conferencias e intercambio tecnológico, lo cual proverá a los profesionistas mexicanos lo más avanzado en informacion técnica, así como de la interrelacion con técnicos extranjeros, integración de los mismos a las actividades de los productores forestales mexicanos, esto con el fin de ubicar a México dentro de la comunidad internacional de productos forestales.

A través de los esfuerzos del Centro, existirá una importante oportunidad para desarrollar la producción de bienes del ecosistema forestal mexicano, así como sus mercados asociados, y aumentar el interés por el bosque en México y Estados Unidos. Asimismo, el Centro representará un modelo a seguir por paises con diversos ecosistemas forestales en America Latina y el mundo. Los esfuerzos de investigación y educación del Centro apoyarán a México a lograr la autosuficiencia y la competitividad internacional en productos forestales.

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Inventario preliminar de aves de la región de Tapalpa, Jalisco, México

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Resumen.—Las aves tienen potencial de uso o aprovechamiento como mascotas, ornato y algunas veces para el consumo humano. El objetivo del presente trabajo fue el inventario de las aves de la región de Tapalpa, Jalisco y determinar su hábitat principal. Las técnicas utilizadas fueron: muestreos y transectos, los cuales se realizaron en las diferentes condiciones que presenta la vegetación; observaciones con binoculares; y colectas con redes con la posterior liberación de los individuos. Se registraron 80 especies comprendidas en 22 familias; el 82% de ellas en áreas con vegetación forestal y el 18% se encuentran relacionadas a las áreas de actividad agropecuaria. La diversidad de las aves en el bosque es una función directa de las condiciones del hábitat y de las diferentes formas de manejo silvícola. Existen especies que solo se encuentran en una condición del área de estudio como: *Aegolius acadicus*, *Dendroica graciao* y *Certhia americana*, lo que indica que son especies estrictas y/o que pueden ser especies indicadoras de las actividades forestales.

INTRODUCCIÓN

Los inventarios de la fauna silvestre producen información necesaria para el manejo del hábitat y para los estudios de impacto ambiental (Franzreb, 1977) y sirven para: 1) Identificar especies con alto valor ambiental que sean sensibles a cambios adversos; 2) Contribuir al conocimiento de los ecosistemas de la región, del país y globalmente; 3) Elaborar los estudios para las manifestaciones de impacto ambiental que exige la legislación mexicana (SEDUE, 1988) y; 4) Caracterizar el medio natural y la fauna silvestre en particular, como lo establecen algunos artículos de la Ley Forestal. En los Estados Unidos de América la importancia que se da a las aves es creciente, tal es el caso del programa de conservación de las aves neotropicales, el cual tiene ahora un mayor apoyo; procurando que un número creciente de especialistas apliquen la biología para la conservación de las especies (Niles, 1992).

Las aves, como otros grupos de especies de fauna, además del valor ecológico, tienen usos para el consumo humano o son aprovechadas para ornato y como mascotas. Algunas especies son características de cierto hábitat, y requieren condiciones ambientales específicas para subsistir (Emlen, 1973). Estas especies tienen un gran valor como indicadoras de la calidad del hábitat.

En general, no se cuenta con suficiente información sobre las aves de la región occidental de México y en particular del estado de Jalisco, por lo que se cuenta sólo con algunas guías de campo (Peterson y Chalif, 1973; Blake, 1953; Robbins *et al.*, 1950; Miller *et al.*, 1957; American Ornithological Union, 1957; Davis, 1972; y Edwards, 1972).

El objetivo de este trabajo fue realizar el inventario de las aves de la región de Tapalpa, Jalisco y determinar su hábitat principal, es decir el bosque o las áreas agrícolas. Con el inventario

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realizado, se contribuyó a fortalecer la base de datos del Sistema de Información Geográfica (GIS) (Baker *et al.*, 1995) que se esta desarrollando como parte de los trabajos del Proyecto de Restauración de Ecosistemas Ribereños (Medina *et al.*, 1995); así como a establecer un punto de referencia sobre la abundancia de poblaciones, la diversidad de especies y la distribución de las aves del país.

ÁREA DE ESTUDIO

Chávez-Huerta *et al.* (1995) describieron el área de estudio como la cuenca del arroyo El Carrizal, de 1,284 Ha, con bosque de pino, localizada 6 Km al suroeste del municipio de Tapalpa, Jalisco, México, en la Sierra de Tapalpa (Figura 1).

La altura sobre el nivel del mar oscila de 2,010 m en la desembocadura del río El Carrizal a 2,420 m en su punto más alto. El clima es templado subhúmedo (García, 1981). La precipitación pluvial media anual es de 901 mm, con un rango que fluctúa de 548 mm para el año más seco a 1,549 mm para el año más lluvioso. El 79% de la precipitación pluvial se presenta durante los meses de junio a octubre (Benavides-Solorio, 1995). La precipitación pluvial durante la época de sequía que comprende los meses de febrero a abril, registra un promedio de tan solo 11 mm por cada mes. Las unidades de suelos son de acuerdo con Gómez-Tagle y Chávez-Huerta (1986): andosoles húmicos, cambisoles y luvisoles crómicos, regosoles éutricos y litosoles.

Figura 1. Localización del área de estudio al sur de la ciudad de Guadalajara, en la Sierra de Tapalpa, Jalisco, México.

La vegetación dominante es caracterizada por masas mezcladas de pinos (*Pinus michoacana* Martínez, *P. ocarpa* Schiede, *P. leiophylla* Schl. et. Cham., *P. douglasiana* Martínez y *P. pseudostrobus* Lindl.), con escasas masas de pino-encino (*Pinus*/*Quercus*) (Benavides-Solorio, 1987). El mejor arbolado con árboles grandes y altos, está localizado de la parte media de las laderas a las crestas de los cerros. En la parte intermedia y hasta las zonas bajas y ribereñas, se encuentran asociaciones de manzanita (*Crategus mexicanus*) y encinos (*Quercus* spp.). En las pendientes más bajas existen masas compuestas por varias especies de árboles, arbustos y enredaderas (Chávez-Huerta *et al.* (1955). Los géneros más comunes son *Arbutus*, *Alnus*, *Ilex*, *Persea* y *Prunus* (Sánchez *et al.*, 1955).

Chávez-Huerta *et al.*(*op. cit.*), describieron que el sitio tiene como actividades principales el pastoreo y la producción de madera. El ganado ha pastorado dentro la cuenca desde que la región fue colonizada en el siglo XVII. Se han encontrado evidencias arqueológicas de los primeros pueblos dentro la cuenca que incluyen casas de roca, restos de aserraderos y fundiciones de hierro. También hay evidencias de una mina de piedra de la que se acarreó roca para la construcción de caminos y calles. El registro de incendios no es preciso, pero se sabe de 2 grandes siniestros ocurridos en la cuenca del arroyo El Carrizal; uno hace 40 años y otro al principio del siglo actual. La actividad actual con más potencial en la región es el turismo y el desarrollo de la hotelería.

MÉTODOS

Para la realización del inventario de las aves se obtuvieron antecedentes bibliográficos en las bibliotecas de la Universidad Nacional Autónoma de México y de la Universidad Autónoma de San Nicolás de Hidalgo. También se revisaron las colecciones científicas con ejemplares obtenidos en la región. Los métodos de campo empleados fueron observaciones auxiliadas con binoculares, colectas con redes, muestreos y transectos realizados en las diferentes condiciones que presenta la vegetación.

Los binoculares empleados tienen una resolución de 7 x 50 y para la identificación de las aves se usaron guías de campo (Peterson y Chalif,

1973; Blake, 1953; Robbins, 1966; y National Geographic Society, 1989). Se realizaron veinte censos de acuerdo a la metodología de Reynolds *et al.*, (1980). También se llevaron a cabo transectos nocturnos de 30 minutos para detectar la presencia de aves, observando a los individuos y escuchando los cantos, con dirección completamente al azar (Rabinovich, 1984; Murie, 1974). La nomenclatura adoptada fue la de American Ornithologists Union (1957) y los nombres comunes adoptados los de Clements (1974), Birkenstein y Tomlinson (1981) y Navarro-Sigüenza (1991).

Los sitios de observación fueron seleccionados con base en el tipo de vegetación, con el fin de cubrir todas las condiciones que presenta la cuenca del río El Carrizal. Se hicieron recorridas de acuerdo a la técnica de transectos lineales de 2,000 m (Emlen, 1971; Verner, 1988), durante los cuales se registró a las especies observadas. A la vez se efectuaron colectas de ejemplares por medio de redes ornitológicas; las aves muy dañadas o muertas en la red, se prepararon para colección científica de acuerdo a Juárez *et al.*(1980).

RESULTADOS

La relación de aves encontradas se presenta en el Cuadro 1. Se registraron 80 especies comprendidas en 22 familias; el 82% de ellas se observaron dentro de la vegetación forestal y el 18% se encontraron en las áreas con actividades agropecuarias.

En el Cuadro 2, se presenta la distribución relativa de las aves por su hábitat mayor, sea bosque o áreas agrícolas. Naturalmente ocurren más especies en el bosque, debido a la diversidad del hábitat. La zona ribereña es posiblemente el área con mayor número de especies y con mayor diversidad, por la complejidad de sus componentes bióticos y abióticos.

DISCUSIÓN DE RESULTADOS

El estudio de las aves centra su interés en el conocimiento de la biología y ecología de las especies, lo cual reviste una gran importancia para México, ya que existe la necesidad de conocer y evaluar los recursos bióticos con que se cuenta y establecer las bases más adecuadas para su protección, menejo y aprovechamiento sostenibles.

El conocimiento de las relaciones entre los organismos y entre éstos y el ambiente, es necesario para el manejo de los ecosistemas y en particular de la fauna de vertebrados que los habita.

Uno de los grupos de vertebrados más estudiados son las aves, principalmente porque muchas de ellas han sido aprovechadas por el hombre con fines comerciales, ya sea con propósitos alimentarios y cinegenéticos o bien con fines de ornato por su belleza o su canto. Su importancia ecológica también es notable, puesto que existen eslabones de consumidores de la cadena alimentaria, que están en relación muy directa con otros miembros de su clase, así como con el esto de la flora y fauna; asímismo por la capacidad de desplazarse con rapidez a distintos ambientes, que las hace uno de los grupos de animales más versátiles.

Estas características, aunadas a las distintas formas de alimentación que tienen, les da una gran importancia científica, económica, cultural y social.

La abundancia de cada población de aves se muestra en el Cuadro 1, donde destacan las siguientes especies en el bosque: *Turdus assimilis, Myadestes obscurus, Pheucticus melanocephalus, Atlepetes piliatus, Aphelocoma ultramarina, Empidonax difficulis, Eugenes fulgens, Caprimulgos vociferus, Aegolius acadicus, Trogodytes aedon, Lepidocolaptes leucogaster, Leoptila verreauxi, Dendroica graciae* y *Certhia americana*. En las zonas agrícolas y en áreas abiertas de pastizales, las especies más observadas fueron: *Pyrocephalus rubinus, Hirundo rustica, Columbina inca, Tyrannus voliferans, Corvus corax, Sialia mexicana* y *Lianus ludovicianus*. Además *Buteo jamaisensis* y *Cathartes aura* se observaron en diferentes ambientes.

En cuanto a la variación por gremios, es notorio que las insectívoras son las más conspicuas en el área de estudio. Ahora bien, dentro del gremio de las insectívoras, existen dos grupos, las que se alimentan de los insectos descortezadores y las que se alimentan de los insectos que atrapan al vuelo.

La comunidad de aves dentro del bosque encontradas durante los transectos realizados en el día, la componen las especies *Myadestes obscurus, Turdus assimilis, Melanotis caerulescens, Catharus aurantiirostris, Mioborus miniatus, Pheuticus melanocephalus* y *Atlapetes piliatus*.

Para el caso de los transectos nocturnos se pueden señalar a *Aegolus acadicus, Caprimulgus vociferus* y *Glaucidium gnoma*, las que fueron además especies que se registraron en un 90% de los muestreos. En las zonas agrícolas las especies más observadas fueron: *Pyrocephalus rubinus, Hirundo rustica, Colombina inca, Tyrannus vociferans, Corvus corax* y *Guiraca caerulea.*

El gremio más importante desde el punto de vista de su abundancia relativa en el área de estudio, fue el de las aves insectívoras, lo cual no es extraño, ya que el hábitat muestreado, está representado por una mezcla de estratos y especies vegetales que dan como consecuencia un gran número de lugares donde se pueden alimentar las aves insectívoras. La importancia esperada de aves

Cuadro 1. Aves de la región de Tapalpa, Jalisco, México.

NOMBRE COMÚN	NOMBRE CIENTÍFICO
Cattle Egret	*Bubulcus ibis*
Turkey Vulture	*Cathartes aura*
Black Vulture	*Coragyps atratus*
Red-tailed Haek	*Buteo jamaicensis*
Gray Hawk	*Buteo nitidus*
American Krestel	*Falco sparverius*
Inca Dove	*Columbina inca*
Withe-tipped Dove	*Leptotila verreauxi*
Groove-billed Ani	*Crotophaga sulcirostris*
Greater Roadrunner	*Geococcyx californianus*
Ferruginous Pygmy-Owl	*Glaucidium brasilianum*
Northern Saw-whet Owl	*Aegolius acadicus*
Whip-poor-will	*Caprimulgus vociferus*
Berylline Hummingbird	*Amazilia beryllina*
White-eared Hummingbird	*Hylocharis leucotis*
Northern Flicker	*Colaptes auratus*
Acorn Woodpecker	*Melanerpes formicicorus*
Cassin's Kingbird	*Tyrannus vociferans*
Dusky-capped Flycatcher	*Myiarchus tuberculifer*
Greater Pewee	*Contopus pertinax*
Tufted Flycatcher	*Mitrephanes phaeocercus*
Least Flycatcher	*Empidonax minimus*
Vermillion Flycatcher	*Pyrocephalus rubinus*
Western Flycatcher	*Empidonax difficilis*
Buff-breasted Flycatcher	*Empidonax fulvifrons*
Rough-wingwed Swallow	*Stelgidopteryx serripennis*
Barn Swallow	*Hirundo rustica*
Scrub Jay	*Aphelocoma coerulescens*
Common Raven	*Corvus corax*
Bushtit	*Psaltriparus minimus*
Brown Creeper	*Certhia americana*
White-breasted Nuthatch	*Sitta carolinensis*
Huose Wren	*Troglodytes aedon*
Blue Mockingbird	*Melanotis caerulescens*
White-throated Robin	*Turdus assimilis*
Brown-backed Solitaire	*Myadestes obscurus*
Hermit Thrush	*Catharus guttatus*
Ruby-crowned Kinglet	*Regulus calendula*
Western Bluebird	*Sialia mexicana*
Orange-billed Nightingale-Thrush	*Catharus aurantirostris*
Gray Silky-Flycatcher	*Ptilogonys cinereus*
Longgerhead Shrike	*Lanius ludovicianus*
Hutton's Vireo	*Vireo huttoni*
Solitary Vireo	*Vireo solitarius*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*
Crecent-chested Warbler	*Vermivora superciliosa*
Yellow-rumped Warbler	*Dendroica coronata*
Townsend's Warbler	*Dendroica townsendi*
Hermit Warbler	*Dendroica occidentalis*
Grace's Warbler	*Dendroica graciae*
Wilson's Warbler	*Wilsonia pusilla*
MacGillivray's Warbler	*Oporornis tolmiei*
Yellow-breasted Chat	*Icteria virens*
Painted Redstart	*Myioborus pictus*
Red-faced Warbler	*Cardellina rubrifrons*
Slate-Throated Redstart	*Myioborus miniatus*
Red Wabler	*Ergaticus ruber*
Golden-crowned Wabler	*Basileuterus culicivorus*
Rofous-capped Warbler	*Basileuterus rufifrons*
Yellow-winged Cacique	*Cacicus melanicterus*
Hooded Oriole	*Icterus cucullatus*
Northern (bullock's) Oriole	*Icterus bullockii*
Streak-backed Oriole	*Icterus pustulatus*
Hepatic Tanager	*Piranga flava*
Western Tanager	*Piranga ludoviciana*
Frayish saltator	*Saltator coerulescens*
Black-headed Grosbeak	
Pheucticus melanocephalus	
Blue Grosbeak	*Guiraca caerulea*
Indigo Bunting	*Passerina cyanea*
Varied Bunting	*Passerina versicolor*
Painted Bunting	*Passerina ciris*
Brown Towhee	*Pipilo fuscus*
Collared Towhee	*Pipilo ocai*
Lark Sparrow	*Chondestes grammacus*
Chipping Sparrow	*Spizella passerina*
Lincoln's Sparrow	*Melospiza lincolnii*
House Sparrow	*Passer domesticus*
Lessr Goldfinch	*Carduelis psaltria*
House Finch	*Carpodacus mexicanus*

Cuadro 2. Distribución relativa y abundancia de especies de aves por tipo de hábitat en Tapalpa, Jalisco, México.

ESPECIES MÁS ABUNDANTES EN EL BOSQUE	ESPECIES MÁS ABUNDANTES EN ÁREAS AGRÍCOLAS
Aphelocoma ultramarina	*Bubulcus ibis*
Empidonax difficilis	*Columbia inca*
Empidonax fulvifrons	*Buteo jamaicensis*
Hylocharis leucotis	*Cathartes aura*
Eugenes fulgens	*Crotophaga sulcirostris*
Caprimulgos vociferus	*Tyrannus vociferans*
Aegolius acadicus	*Myarchus cinerascens*
Glaucidium gnoma	*Pyrocephalus rubinus*
Leoptila verreauxi	*Hirundo rustica*
Geococcyx californianus	*Corvus corax*
Certhia americana	*Sialia mexicana*
Sitta carolinensis	*Lanuius ludovicianus*
Troglodytes aedon	*Guiraca caerulea*
Regulus calendula	*Aimophila ruficeps*
Catharus guttatus	*Molothrus ater*
Turdus assimilis	
Vermivora celata	
Wilsonia pusilla	
Myoborus miniatus	
Pheucticus melanocephalus	
Myadestes obscurus	
Melanotis caerulescens	
Lepidocolaptes leucogaster	
Catharus aurantirostris	
Myioborus pictus	
Atlapetes pilieatus	

insectívoras no está bien documentada. Existe suficiente información para citar los grandes beneficios derivados de ellas; algunos que menciona Otvos (1979) son: 1) Su influencia en la dinámica de poblaciones de muchos insectos forestales por su depredación directa y por su influencia indirecta sobre los parásitos de insectos y de los predatores de presa, al desencadenar agentes patógenos autógenos; o bien por cambiar el micro-hábitat de la presa; 2) Su efecto al suprimir y retardar la acumulación progresiva a niveles epidémicos y por incrementar el intervalo entre la explosión de la plaga y su declinación; 3) La dispresión de semillas de varias plantas; y 4) La descomposición de varios hongos que causan pudriciones y que al destruirse se incorporan al ciclo de nutrientes.

CONCLUSIONES

Las aves, principalmente las omnívoras, por sus hábitos alimentarios y de anidamiento, pasan la mayor parte del tiempo cerca del nivel del suelo donde se alimentan de insectos o productos vegetales. Algunas poblaciones de aves como los pájaros carpinteros y los trepatroncos, consumen grandes cantidades de insectos descortezadores de los pinos. Numerosas aves dispersan semillas y plantan hemiparásitas. También existen aves que juegan un papel importante en la polinización, como es el caso de los colibríes. Debido a éstas interacciones, es bien conocido el uso de las aves para el diagnóstico de la sanidad de los ecosistemas (Maurer, 1992).

La diversidad y abundancia de las aves en el bosque es una función directa de las condiciones del hábitat y de las diferentes formas de manejo silvícola. Además, las áreas ribereñas son un hábitat de gran importancia para la mayoría de las especies. En las áreas ribereñas del suroeste de los Estados Unidos de América, se ha determinado que más de 60% de las especies de aves neotropicales usan este tipo de hábitat durante sus migraciones y para criaderos (Krueper, 1992). Stevens *et al.* (1977) determinó que las áreas ribereñas contienen 10 veces más aves migratorias por hectárea que otros hábitat. Una de las razones es la calidad y diversidad de los hábitat ribereños, por lo que debe tenerse una mayor protección y cuidado de las cuencas.

Existen especies que solo se encontraron en una sola condición de la cuenca, lo que sugiere que son especies estrictas y que pueden ser especies indicadoras. Es recomendable continuar las investigaciones relativas a las aves y su potencial en la cuenca del arroyo El Carrizal, que puedan sustentar cada vez mejor el diagnóstico de la calidad del ecosistema.

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Inventario preliminar de los mamíferos de la región de Tapalpa, Jalisco, México

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Resumen.—Existen especies de mamíferos de las que se puede obtener información sobre la utilización del ecosistema y sus alteraciones. El objetivo de este trabajo fue realizar el inventario de las especies de mamíferos de la región de Tapalpa y relacionar la presencia de algunas especies con la época del año. Los métodos empleados fueron la colecta con trampas y la observación de rastros y huellas. Se identificaron 46 especies de 8 órdenes y 18 familias. Las más comunes son las siguientes: *Muridae* (12 spp), *Phillostomatidae* (8 spp), *Vespertilionidae* (4 spp), *Mormoopidae* (3 spp). Se registraron nueve especies de mamíferos medianos. La importancia del conocimiento de la diversidad de los mamíferos en los distintos tipos de vegetación radica en el entendimiento de las relaciones ecológicas para tomar decisiones sobre el manejo y control de las poblaciones de mamíferos que dañan la productividad agrícola y/o forestal de la región.

INTRODUCCIÓN

Poca es la importancia que se ha dado al valor económico y ecológico de los mamíferos pequeños. Existe muy poca información cuantitativa y cualitativa de las poblaciones de mamíferos de México. La utilización de estas especies para producir alimentos, fibras y otros productos, afecta sus poblaciones, que existen en forma natural en convivencia con el ser humano. Estos problemas se presentan en diferentes, condiciones tales como huertos, tierras de cultivo, pastizales y bosques.

Casi siempre los mamíferos implicados son roedores de varias clases, causantes de daños a los productos agrícolas que el hombre destina para su propio uso. Algunas especies causan grandes problemas y resulta costoso reducir el impacto mediante el uso de venenos, rodenticidas y otras formas de control. También hay especies benéficas como el venado, diferentes tipos de conejos y otras especies que se utilizan para consumo humano.

No obstante que algunos mamíferos pequeños impactan en forma negativa al bosque y a la agricultura al consumir semillas y granos (Campbell, 1976 y Sánchez, 1978), también tienen un gran valor ecológico. Las acciones positivas que realizan estas especies son la aereación e hidratación del suelo, depredación de insectos y la dispersión de esporas de hongos micorrízicos (Hamilton y Cook, 1940; y Maser *et al.*, 1978). Las ardillas arbóreas son bien conocidas como un eslabón importante en los ciclos de nutrientes, de germinación de semillas y de regeneración de los bosques de pino (Maser, 1994). Su ausencia en el ecosistema repercute en una regeneración pobre de las masas de pinos. Existen especies de mamíferos que son indicadoras ecológicas de como se esta utilizando el recurso. Además estas poblaciones de mamíferos pueden ser útiles para determinar el grado de deterioro que sufre el ecosistema, ya que algunas se pueden adaptar a los cambios en los ecosistemas. Lo importante es el equilibro en el

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ecosistema y mantener las poblaciones adecuadas con suficiente diversidad (composición de la mastofauna), para que éstas aumenten su productividad en beneficio del hombre. De esta forma se puede contribuir a usar la ecología para mejorar y sostener la economía del la región.

Los pequeños mamíferos, desde otro punto de vista ecológico, ofrecen una importante fuente de alimento para las aves de presa y mamíferos predatores (Hamilton y Whitaker, 1979). El conocimiento de sus hábitat específicos y su relativa abundancia, puede facilitar la toma de decisiones en el manejo ecológico de estas comunidades.

En la región de Tapalpa, Jalisco, son nulos los estudios de fauna, especialmente de los mamíferos pequeños. Para el estado de Jalisco existen algunos trabajos referentes a los mamíferos, realizados mediante colectas o bien, trabajos generales que aportan conocimientos de los mamíferos existentes para el estado. Hay pocos trabajos que reporten el tamaño de las poblaciones de pequeños mamíferos en los diferentes ecosistemas. Estos pueden ser útiles para las actividades de restauración del hábitat en zonas que presenten cambios muy drásticos o bien en áreas donde ha sido modificado algún elemento, como puede ser un incendio forestal de grandes proporciones. Hall (1981) realizó un estudio muy detallado de los mamíferos de Norteámerica y menciona 140 y 131 especies que se pueden encontrar en los estados de Michoacán y Jalisco, respectivamente. Uno de los trabajos de mayor importancia desde el punto de vista mastozoológico, realizado por Ceballos y Galindo (1984), reportó 9 ordenes que se han registrado para el valle de México y que existen especies de los órdenes insectívora y rodentía que se presentan en el estado de Jalisco.

Muchas poblaciones de las especies de mamíferos están bastante reducidas por las actividades del hombre, ya sea cacería excesiva o la agricultura y la silvicultura. Son muchas las causas de la baja densidad y diversidad de los mamíferos, ya sea por la necesidad de producir alimentos, fibras y otros productos comerciales o por ocio; el resultado es igual, se disminuyen las poblaciones de la fauna.

El fraccionamiento del hábitat es un factor muy importante que contribuye en forma negativa al problema de uso intensivo de los recursos. Un uso práctico de los resultados del presente trabajo es el desarrollo de estudios del impacto ambiental, necesario para cumplir los requisitos para obtener una autorización para aprovechamiento forestal.

El objetivo del presente trabajo fue realizar el inventario de las especies de mamíferos de la región de Tapalpa y relacionar la presencia de algunos especies con las época del año.

ÁREA DE ESTUDIO

Chávez-Huerta *et al.* (1995) describieron el área de estudio como la cuenca del arroyo El Carrizal, de 1,284 Ha, localizada a 6 Km al suroeste del municipio de Tapalpa, Jalisco, México, en la Sierra de Tapalpa (Figura 1). Con fluctuación de su altitud de 2,010 m en la unión del arroyo El Carrizal a 2,420 m en el punto más alto. El clima es templado y subhúmedo (García, 1981). La precipitación pluvial media anual es de 901 mm, con un rango que fluctúa entre 548 mm para el año más seco y 1,549 mm para el año mas lluvioso. El 79 % de la precipitación pluvial ocurre durante los meses de junio a octubre (Benavides-Solorio, 1995). La precipitación pluvial durante la época de sequía, que es de febrero a abril, registra un promedio de tan solo 11 mm por mes. Las mayores unidades de suelos son: andosoles húmicos, cambisoles y luvisoles crómicos, regosoles eútricos, y litosoles (Gómez-Tagle R. y Chávez-Huerta, 1986).

Figura 1. El área de estudio está localizada al sur de la ciudad de Guadalajara, en el Estado de Jalisco, México.

La vegetación dominante la constituyen masas mezcladas de pinos (*Pinus michoacana* Martínez, *P. oocarpa* Schiede, *P. leiophylla* Schl. *et* Cham., *P. douglasiana* Martínez y *P. pseudostrobus* Lindl.), con algunas masas de pino-encino (*Pinus/Quercus*) (Benavides-Solorio, 1987). Las mejores masas , con árboles grandes y altos, se localizan de la parte media de las laderas hasta las crestas. De la parte media hacia abajo y en las zonas ribereñas, son comunes las asociaciones de manzanita (*Crategus mexicanus*) y encinos (*Quercus* spp.). En las partes más bajas se presentan diversas especies de árboles, arbustos y enredaderas (Chávez-Huerta *et al.*, 1995). Los géneros más comunes son son *Arbutus, Alnus, Ilex, Persea,* y *Prunus* (Madrigal *et al.*, 1995).

Chávez-Huerta *et al.* (1995) describieron el sitio con actividades de pastoreo y producción de madera. El ganado ha pastoreado dentro de la cuenca desde que la región fue colonizada en el siglo XVII. Hay evidencias arqueológicas de los primeros pueblos dentro de la cuenca que incluyen casas de roca, restos de aserraderos y fundiciones de hierro. También hay una mina de piedra, de la que se acarreaba roca como material para la construcción de caminos y calles. Hay evidencias de 2 grandes incendios ocurridos en la cuenca del arroyo El Carrizal; uno hace 40 años y el otro a principio de este siglo. Las actividades con mayor impacto potencial en la región son el turismo y la recreación.

MÉTODOS

Los pequeños mamíferos se estudiaron utilizando trampas Sherman colocadas en 2 lineas de 25 estaciones con dos de ellas en cada estación. El cebo que se utilizó fue una mezcla de crema de cacahuate (20 %) y avena (80 %). Las lineas se revisaron durante 15 días continuos. Se conserva la piel y cráneo de los ejemplares colectados, de los que se tomaron las medidas más usuales. Para el caso de los mamíferos medianos, se usaron métodos como el de transectos y localización de rastros o signos de la presencia de los animales (Rabinovich, 1980; Murie, 1974) y el método de estaciones con láminas para impregnación de huellas, con cebo de atún y/o pedazos de fruta para atraer a los animales. Los murciélagos se capturaron colocando 5 redes durante la noche dentro de la vegetación. La selección de los sitios de colecta fue completamente al azar.

Teer (1979) señala que las especies exóticas son aquellas que no son nativas de un lugar, introducidas directa o indirectamente por el hombre, que en la mayoría de los casos ocasionan perjuicios a las poblaciones de la fauna silvestre nativas. En esta zona se presenta el perro (*Canis familiares*) y el ganado residente, tanto en el área forestal, como en las zonas agrícolas. El ganado, aunque lo constituyen animales mamíferos no fue muestreado.

RESULTADOS

Las 46 especies de mamíferos encontradas en la región de Tapalpa, Jalisco, se agrupan en 8 órdenes y 18 familias; las cuales se presentan en Cuadro 1. De acuerdo a lo anterior, los pequeños mamíferos fueron los representados por más especies. Las familias más comunes con el número de especies encontradas fueron: *Muridae* 12, *Phillostomatidae* 8, *Vespertilionidae* 4 y *Mormoopidae* 3.

En el Cuadro 2 se presentan las especies de mayor frecuencia durante las diferentes temporadas del año. Los grupos de especies de mamíferos más observadas fueron los predatores y los omnívoros. Animales especializados como la comadreja se observaron muy poco, lo cual indica que posiblemente no se presentan las condiciones de hábitat deseables como cobertura, comida o agua. Se sabe que este mamífero es muy dificil de observar.

DISCUSIÓN DE RESULTADOS

Para hacer el inventario de la mastofauna del lugar, es necesario contar con el mayor número de zonas muestreadas posible, ya que es un área en la que se realizan actividades silvícolas y turísticas y la variedad de especies puede cambiar mucho de un lugar a otro. Es importante contar con un listado completo de los mamíferos de esta área, puesto que serviría de apoyo a futuras investigaciones y también a la toma de decisiones sobre el manejo de los recursos. Hasta el momento, se reportan 46 especies de mamíferos incluidas en 8 órdenes, teniendo la certeza de que existen más

Cuadro 1. Lista preliminar de mamíferos para la región de Tapalpa.

FAMILIA	NOMBRE CIENTÍFICO
DIDELPHIDAE	*Didelphis virginiana*
SORICIDAE	*Sorex saussurei*
EMBALLONURIDAE	*Balantiopteryx plicata*
MORMOOPIDAE	*Mormoops megalophylla*
	Pteronotus davyi
	Pteronotus parnellii
PHYLLOSTOMIDAE	*Hylonycteris underwoodi*
	Leptonycteris sanborni
	Carollia subrufa
	Artibeus jamaicensis
	Artibeus toltecus
	Sturnira lilium
	Desmodus rotundus
VESPERTILIONIDAE	*Lasiurus borealis*
	Lasiurus intermedius
	Myotis fortidens
	Rhogeessa parvula
MOLOSSIDAE	*Molossus ater*
DASYPODIDAE	*Dasypus novemcinctus*
LEPORIDAE	*Sylvilagus floridanus*
SCIURIDAE	*Spermophilus variegatus*
	Sciurus colliaei
CEOMIDAE	*Pappogeomys gymnurus*
HETEROMYIDAE	*Liomys irroratus*
MURIDAE	*Baiomys musculus*
	Neotoma mexicana
	Peromyscus banderanus
	Peromyscus boylii
	Peromyscus perfulvus
	Peromyscus spicilegus
	Reithrodontomys fulvescens
	Reithrodontomys megalotis
	Reithrodontomys sumichrasti
	Sigmodon fulviventer
	Sigmodon mascotensis
	Mus musculus
	Rattus rattus
CANIDAE	*Canis latrans*
	Urocyon cinereoargenteus
PROCYONIDAE	*Bassariscus astutus*
	Procyon lotor
MUSTELIDAE	*Mustela frenata*
	Conepatus mesoleucus
FELIDAE	*Lynx rufus*
CERVIDAE	*Dama virginianus*

especies. Lo anterior apoyado en el hecho de que para el estado de Jalisco se han reportado aproximadamente 147 especies de mamíferos (Hall, 1981; Ramírez-Pulido *et al.*, 1982; Ramírez-Pulido y Castro-Campillo, 1990; Ceballos y Miranda, 1986).

En el Cuadro 1 se presenta la relación de los mamíferos presentes en el área forestal de Tapalpa, Jalisco, que incluye especies de mamíferos medianos como: *Canis latrans*, *Urocyon cinereoargenteus*, *Bassariscus astutus*, *Procyon lotor*, *Mustela frenata*, *Conepatus mesoleucus*, *Lynx rufus*, *Dama virginianus*, *Dasypus novencinctus*, *Sylvilagus floridanus*, y *Sciurus colliaei*. Para estas especies se cuenta con registros de observaciones directas y de localización de rastros como huellas, excrementos, cavernas y conos roídos.

Como puede apreciarse en la relación, en el área forestal se encuentran especies tan importantes como el venado cola blanca, la cual debe de seguir siendo conservada a pesar de la disminución del número de individuos, según información proporcionada por los habitantes de Tapalpa; esta condición es muy parecida a la de otras zonas forestales del país como lo mencionan Mandujano y Hernández-Arellano (1986) y Ceballos y Galindo (1984), para una área protegida en la Sierra del Ajusco en donde la especie ha sido cazada indiscriminadamente.

La frecuencia con la que han sido observadas las especies en los transectos realizados se presenta en el Cuadro 2. Si bien el tipo de muestreo realizado, la actividad del animal, las perturbaciones del ambiente, los aprovechamientos forestales y los incendios forestales, son algunos factores que influyen de manera importante en la frecuencia con la que se observa cada especie, la información obtenida es un indicador de la abundancia relativa de las poblaciones de mamíferos medianos. De esta manera las especies más frecuentemente observadas serán, en general, más abundantes y viceversa. El venado cola blanca, el conejo, el mapache, la ardilla arbórea, el coyote, la zorra, el zorrillo y el tlacuache, son las especies que se han registrado con mayor frecuencia a lo largo del año y durante los muestreos. Otras como el cacomixtle, el gato montés, la comadreja, el armadillo y el ardillón, no han sido registradas en todas las estaciones y cuando se han observado, los rastros son regularmente escasos.

Cuadro 2. Frecuencia de observación por temporada y total del año 1994 de algunas especies de mamíferos en Tatalpa, Jalisco, México.

	TEMPORADA DEL AÑO 1994				
ANIMAL	PRIMAVERA	VERANO	OTOÑO	INVIERNO	TOTAL
Ardilla (Collie's squirrel) *Sciurus colliaei*	11	10	9	5	3
Ardillón (Rock squirrel) *Spermophilus variegatus*	6	8	7	5	26
Armadillo (Nine-banded armadillo) *Dasypus novemcinctus*	4	5	4	31	6
Conejo (Eastern cottontail) *Sylvilagus floridanus*	10	1	4	4	19
Cacomixtle (Ringtail) *Bassariscus astutus*	2	-	1	1	3
Comadreja (Long-tailed weasel) *Mustela frenata*	3	-	-	1	4
Coyote (Coyote) *Canis latrans*	8	2	4	7	21
Gato mont,s (Bobcat) *Lynx rufus*	2	1	-	1	4
Mapache (Raccoon) *Procyon lotor*	6	7	2	8	23
Tlacuache (Virginia opossum) *Didelphis virginianus*	9	7	8	5	29
Zorra (Gray fox) *Urocyon cineroargenteus*	6	8	5	8	27
Zorrillo (Hog-nosed skunk) *Conepatus mesoleucus*	9	10	4	4	27
Venado (White-tailed deer) *Dama virginianus*	7	5	3	10	25

El número de transectos se indica en las columnas de la temporada. Los nombres comunes en inglés se encierran en paréntesis.

CONCLUSIONES

En las áreas forestales de Tapalpa, habitan por lo menos 46 especies de mamíferos silvestres y se puede considerar a esta área como un hábitat potencial de otras 4 especies. El listado de especies contiene una buena proporción de carnívoros y omnívoros. Esto es un buen indicador de que hay condiciones deseables para estas especies. Para tener un mejor conocimiento de las especies de mamíferos del área, es necesario continuar el inventario para detectar las especies más raras, como aquellas de la familia de los felinos (*Felis onca, F. concolor, F. pardalis, F. wiedii*, o *F. tigrina*) o de los lobos (*Canis lupus*). Esta clase de mamíferos son importantes porque representan a las especies del nivel más alto de la cadena. Su ausencia indica que algo está mal, ya sea su hábitat, sus presas ó el hábitat de éstas. Estos grupos de especies servirán para el diagnóstico del ambiente.

Donde se encuentra fraccionada la vegetación natural, es urgente que se mantenga la menor alteración, bajo un programa silvícola bien definido. El factor más grave que causa la declinación de las poblaciones de fauna silvestre es la pérdida del hábitat (Morrison *et al.*, 1992). Es muy difícil evaluar los efectos en el hábitat, pero esta claro que sucede en condiciones donde prosperan especies que tienen grandes rangos de distribución.

Los bosques de la zona de Tapalpa constituyen una reserva de mastofauna característica de la parte Occidental de México y de los bosques de clima templado. La fauna que habita los bosque de la región de Tapalpa, bajo un plan de manejo adecuado, puede contribuir como elemento enriquecedor de la vida cultural de la población local y de los visitantes de esta zona a través de programas de educación ambiental, ecoturismo y otras alternativas de conservación de los recursos naturales.

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Creacion de arboles para fauna silvestre en Bosques Bajo Manejo por medio de un hongo saprófito

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Resumen.—Un método para crear las condiciones de pudrición de madera requeridas por los excavadores de cavidades, es probado en seis rodales del noreste de Oregon. Resultados preliminares indican que después de cinco años, el 50 porciento de los árboles inoculados artificialmente en un rodal, están siendo usados por especies que hacen nidos en las cavidades. Todos los árboles inoculados siguen vivos con copas viables. Debido a la biología y abundancia natural en el aire de las esporas del hongo saprófito usado, no hay posibilidad de dispersión en árboles no objetivo. Estos resultados preliminares sugieren que la inoculación puede ser una herramienta viable para crear el hábitat adecuado, en mayor abundancia o a edades más jóvenes de las que ocurrirían en forma natural, para fauna dependiente de pudriciones en bosques de coníferas.

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¿Como se atendieros los aspectos de la fauna silvestre en del área de manejo del ecosistema del Río Sacramento?

Danney Salas[1] y Tim Meyer[1]

Resumen.—El Area del Ecosistema del Rio Sacramento, dentro del Bosque Nacional Lincoln, incluye varias zonas que abarcan aproximadamente 47,000 acres de diversos paisajes, que van desde bosques mezclados de coníferas a desiertos de matorrales. La condición general deseada para esta área, es la de un ecosistema flexible que integre valores y necesidades sociales dentro del paisaje. Cinco parámetros descriptivos fueron usados para definir la referencia, la condición actual, y las condiciones deseables: el tipo de vegetación; el estado estructural de la vegetación; el rango de condiciones; la condición del arroyo; y el clima social. Se identificaron los componentes críticos del habitat para cuatro especies (Mexican spotted owl, northern goshawk, rocky mountain elk, y mule deer)y se relacionaron con el tipo de vegetación y/o estructura. Se analizó el efecto de los parámetros de vegetación sobre cada una de las cuatro especies.

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